PREFACE

The Ministry of Urban Development and Poverty Alleviation (MoUD&PA), Government of India, has taken several initiatives towards good urban governance and making urban local bodies as self-sustaining viable entities of local self-government.

Urban sector reforms have been identified as thrust areas by the Ministry and tools such as City Challenge Fund, Pooled-Finance Development Fund, Urban Reforms Incentive Fund have been conceived. Private Sector Participation guidelines have been framed and switching over to accrual-based accounting have been emphasized.

To supplement the Urban Reform agenda, MoUD&PA has developed the Model Municipal Law, to assist urban local bodies in the areas of accounting reforms, resource mobilization and entry of private sector partnership. The Model Municipal Law inter-alia aims at simplification of municipal bylaws, provision for enhanced borrowing, allowing the entry of private sector and authorising concessionaires to penalise users for non-payment of tariffs.

This initiative is expected not only to enhance the capacities of ULBs to leverage public funds for development of urban sector but also will help in creating an environment in which urban local bodies can play their role more effectively and ensure better service -delivery.

MoUD&PA is thankful to Indo-USAID FIRE project and its consultant Times Research Foundation for the assistance in drafting the Model Municipal Law.

We hope this Model Municipal Law will facilitate and assist State Governments in amending/enacting State level Municipal statutes, mutates-mutandis.

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DRAFT

F O R E W O R D

Solid Waste Management has been one of the neglected areas of urban management activities in India. By and large, in cities and towns hardly 50 per cent of the solid wastes generated are collected, transported and disposed off, giving rise to insanitary conditions and diseases, especially amongst the urban poor who constitute about 35 per cent of the urban population.

It is estimated that out of one billion people living in the country about 300 million reside in urban areas. It is likely that 40 per cent of the urban population would be residing in 40 Metros by 2001. The situation is frightening, big towns are becoming bigger, bigger ones are becoming metros and metropolises are becoming mega-polises. Concerned Urban Local Bodies responsible for providing the basic services like Water Supply, Sewerage and Solid Waste Management and other amenities to the people are finding it increasingly difficult to copeup with the demand due to fast growth of urban population, thereby adversely affecting the management of such services to the people.

Efficient garbage collection, transportation and disposal are among the vital functions of Urban Local Bodies. Despite the fact that a large number of staff is employed by them to discharge this function and a substantial portion of their annual budget is spent only on garbage collection, transportation and disposal, the situation in the towns and cities remains far from satisfactory. The issue of recycling of solid waste has not received due attention. With the solid waste generation increasing with time, the importance of recycling needs to be recognized and given due importance.

The continuous deterioration of quality of life in urban areas has underlined the need to create better environmental conditions and evolve a workable national strategy for solid waste management. As a follow-up, the Ministry of Urban Development had constituted an Expert Committee in February, 1998 for preparation of ***"Manual on Municipal Solid Waste Management"***. The Expert Committee had done a commendable job and brought out the Manual, which is now available to the Urban Local Bodies and other User Agencies to guide them for planning, designing and implementation of solid waste management projects in urban areas.

I am confident that the Urban Local Bodies and other service providers will find this Manual very useful as a practical tool for discharging their day to day functions in a more effective, efficient and sustainable manner with respect to Municipal Solid Waste Management.

{ JAGMOHAN }

A N N E X U R E S

Annexure 1.1 Municipal Wastes (Management & Handling Rules, 1999)

Annexure 5.1 Environment (Protection) Act, 1986

Annexure 5.2 Guidelines for Financial Assistance for Setting up of Slaughter Houses and Carcass Utilization Centres

Annexure 5.3 Draft Guidelines for Sanitation in Slaughter Houses

Annexure 6.1 Categories of Industries to be restricted for their operation in Non-Conforming areas

Annexure 7.1 Solid Wastes – Hospitals – Guidelines for Management

Annexure 7.2 Bio-Medical Waste (Management & Handling) Rules, 1998

Annexure 7.3 List of States where Prescribed Authority has been set up for supervising the Implementation of the Bio-Medical Waste (Management & Handling) Rules

Annexure 7.4 Comparison of Treatment Technologies for "Bio-Medical Waste"

Annexure 7.5 Schematic of pit for deep burial of Cate Goryi-Bio-Medical Waste (based on Bio-Medical Waste Management Handling Rules)

Annexure 12.1 The Specification for Construction of Waste Storage Depot

Annexure 12.2 General Specification of 7 cu.mt. capacity Garbage Containers to be handled by 7 cu.mt. D.P. units

Annexure 13.1 Hydraulic Vehicle Inspection Schedule

Annexure 13.2 Schedule of Maintenance of Trucks & Vehicles

Annexure 13.3 Minimum equipments/tools required for workshop to Maintain a fleet of up to 50 Vehicles

Annexure 15.1 Waste to Energy Case Studies

Annexure 15.2 Ministry of Non-Conventional Energy Sources

Annexure 17.1 Estimation of Landfill Capacity, Landfill Height, Landfill Area

Annexure 17.2 Typical Example (Preliminary Design)

Annexure 17.3 Estimation of Landfill Cost based on Preliminary Design

Annexure 19.1	Typical Organizational Chart for a activity of 30 lacs Population
Annexure 19.2	Brief Course Content for Training to various Levels of Staff/Officers.
Annexure 20.1	Government of Tamil Nadu
Annexure 21.1	Cost estimates for Modernization of Solid Waste Management Practices in Urban Areas
Annexure 21.2(a)	Salient Features of Ministry of Agriculture Guidelines for Recovery of Compost from Urban/Municipal Waste
Annexure 21.2(b)	HUDCO's Financing
Annexure 21.2(c)	An Example : Financing Hospital Waste Management Schemes by HUDCO
Annexure 22.1	Impact Identification Network for Collection System
Annexure 22.2	Impact Identification Network for Disposal System
Annexure 23.1(a)	Daily Monitoring on Collection of Waste from Waste Storage Depot
Annexure 23.1(b)	Primary Collection Operation Summary Table
Annexure 23.2(a)	Monitoring of Transfer Stations Operations (Entry Record Sheet)
Annexure 23.2(b)	Record of Transfer of Waste from Transfer Stations to Disposal Site
Annexure 23.3(a)	Vehicle Movement Monitoring
Annexure 23.3(b)	Vehicle Utility Monitoring
Annexure 23.3(c)	Monitoring Fuel Consumption
Annexure 23.3(d)	Drivers Attendance Monitoring
Annexure 23.3(e)	Vehicle Repair Report
Annexure 23.3(f)	Monitoring Cost of Operations
Annexure 23.4	Monitoring of Landfill Operation
Annexure 23.4(a)	Daily Waste Disposal Record Sheet for Zone
Annexure 23.4(b)	Monitoring Waste Disposal from all Zones/Divisions

Annexure 23.4(c)	Monthly Record Sheet of Waste Disposal
Annexure 23.4(d)	Equipment Performance Report
Annexure 23.4(e)	Carbon Utility Report
Annexure 23.4(f)	Operating Cost Summary Table
Annexure 23.4(g)	Disposal Cost Summary
Annexure 23.4(h)	Waste Processing Report
Annexure 23.5(a)	Project Information Report
Annexure 23.5(b)	Project Monitoring Report (Name of the Project/Value of the Project)
Annexure 23.6(a)	Financial and Economical Information – Revenue Receipts
Annexure 23.6(b)	Revenue Expenditure
Annexure 23.6(c)	Capital Receipts
Annexure 23.7(a)	Monitoring of Court Cases
Annexure 23.7(b)	Enforcement Measures

CONTENTS

1	**INTRODUCTION**	1
1.1	PREAMBLE	1
1.2	PROBLEMS BEING FACED BY URBAN LOCAL BODIES	3
1.3	NEED FOR A MANUAL ON SOLID WASTE MANAGEMENT	3
1.4	CONSTITUTION OF THE EXPERT COMMITTEE & METHODOLOGY ADOPTED	4
2.	**PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT**	5
2.1	INTRODUCTION	5
	2.1.1 Solid Waste Generation	5
	2.1.2 Environmental Impact of Solid Waste Disposal on Land	5
	2.1.3 Objective of Solid Waste Management	9
2.2	PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT	9
	2.2.1 Waste Reduction	9
	2.2.2 Effective Management of Waste	11
	2.2.3 Functional Elements of Municipal Solid Waste Management	13
2.3	HIERARCHY OF WASTE MANAGEMENT OPTIONS	16
2.4	WASTE MINIMISATION	17
2.5	RESOURCE RECOVERY THROUGH MATERIAL RECYCLING	19
	2.5.1 Sorting at Source	19
	2.5.2 Centralised Sorting	20
	2.5.3 Sorting Prior to Waste Processing or Landfilling	20
2.6	RESOURCE RECOVERY THROUGH WASTE PROCESSING	20
	2.6.1 Biological Processes	21
	2.6.2 Thermal Processes	21
	2.6.3 Other Processes	22
2.7	WASTE TRANSFORMATION (WITHOUT RESOURCE RECOVERY) PRIOR TO DISPOSAL	22
	2.7.1 Mechanical Transformation	22
	2.7.2 Thermal Transformation	23

2.7.3 Other Methods 23
2.8 DISPOSAL ON LAND 23
2.9 COMPONENTS OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM 23
2.10 LINKAGES BETWEEN MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM AND OTHER TYPES OF WASTES GENERATED IN AN URBAN CENTRE 26
2.11 MATERIALS FLOW CHART FOR MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM (1000 t.p.d. WASTE GENERATION) 29
3. COMPOSITION AND QUANTITY OF SOLID WASTE 32
3.1 INTRODUCTION 32
3.1.1 Terminology and Classification 32
3.1.2 Variations in Composition and Characteristics 32
3.2 DEFINITIONS AND CLASSIFICATION OF SOLID WASTES 33
3.2.1 Definitions 33
3.2.2 Classification 36
3.3 COMPOSITION, CHARACTERISTICS AND QUANTITIES 38
3.3.1 Need for Analysis 38
3.3.2 Field Investigations 38
3.3.3 Number of Samples to be collected 40
3.3.4 Collection of Samples of Solid Waste 43
3.3.5 Composition and Characteristics 43
3.3.5.1 *Characteristics of Municipal Solid Waste in Indian Urban Centres* 45
3.3.6 Quantities 47
3.3.6.1 *Per Capita Quantity of Municipal Solid Waste in Indian Urban Centres* 47
3.3.6.2 Estimation of Future Per Capita Waste Quantity 48
3.3.6.3 Relation between Gross National Product and Municipal Solid Waste Generation 48
3.3.6.4 Rate of Increase Based on Experience in Other Cities 50
3.3.6.5 Seasonal Variations 50
3.3.7 Physical Characteristics 50
3.3.7.1 Density 50

		3.3.7.2 *Moisture Content*	52
		3.3.7.3 *Size of Waste Constituents*	52
		3.3.7.4 *Calorific Value*	52
	3.3.8	Chemical Characteristics	53
		3.3.8.1 *Classification*	53
3.4	CONCLUSION		55
4.	**CONSTRUCTION AND DEMOLITION WASTE**		56
4.1	INTRODUCTION		56
4.2	CHARACTERISTICS		57
4.3	STORAGE OF CONSTRUCTION AND DEMOLITION WASTE		58
4.4	COLLECTION AND TRANSPORTATION		59
4.5	RECYCLING AND REUSE		59
4.6	DISPOSAL		60
4.7	PLANNING AND MANAGEMENT ASPECTS		60
4.8	INSTITUTIONAL AND REGULATORY ASPECTS		61
5.	**SLAUGHTER HOUSE WASTE AND DEAD ANIMALS**		63
5.1	INTRODUCTION		63
5.2	MAGNITUDE OF THE PROBLEM		63
5.3	CLASSIFICATION		66
5.4	OPERATIONS DURING SLAUGHTERING OF ANIMALS		66
	5.4.1	Present Scenario	66
		5.4.1.1 *Slaughtering*	66
		5.4.1.2 *Bleeding*	67
		5.4.1.3 *Dressing*	67
		5.4.1.4 *Evisceration*	67
5.5	MEASURES PROPOSED TO IMPROVE THE SLAUGHTER HOUSE WASTE MANAGEMENT		67
	5.5.1	Liquid Waste/Effluent	67
	5.5.2	Collection of Blood	68
	5.5.3	Improved Method of Dressing	68
	5.5.4	Evisceration	68
	5.5.5	Safe Disposal of Waste Products	68
	5.5.6	Odours Control	69
	5.5.7	Modernization of Slaughter House	69

5.5.8 Curbing Activities of Illegal Slaughtering of Animals 69
5.5.9 Provision of Dry Rendering Plants 70
5.6 CONCLUSION 70
6. INDUSTRIAL SOLID WASTE 71
6.1 INTRODUCTION 71
6.2 THE PROBLEMS 72
6.3 INDUSTRIAL SOLID WASTE 72
6.4 DESCRIPTION OF IMPORTANT INDUSTRIAL SOLID WASTE 73
6.4.1 Coal Ash 73
6.4.2 Integrated Iron & Steel Plant Slag 74
6.4.3 Phosphogypsum 74
6.4.4 Red Mud 74
6.4.5 Lime Mud 75
6.4.6 Waste Sludge and Residues 75
6.4.7 Potential Reuse of Solid Wastes 75
6.5 WASTE MANAGEMENT APPROACH 75
6.5.1 Prevention – A Waste Minimization Approach 75
6.5.2 Waste Management at Source 80
6.5.3 Cutting down waste generation at Source 80
6.5.4 Recycle and Reuse of wastes generated 80
6.5.5 Waste Minimization 80
6.5.6 Treatment and disposal of residual waste 81
6.6 AREA OF APPLICATION OF SOME IMPORTANT INDUSTRIAL WASTES 81
6.7 CURRENT PRACTICE OF INDUSTRIAL SOLID WASTE MANAGEMENT 83
6.7.1 Collection and Transport of Wastes 83
6.7.2 Storage and Transportation 83
6.7.3 Disposal of Industrial Solid Waste 84
6.8 HEALTH CONSEQUENCES OF POOR INDUSTRIAL WASTE DISPOSAL 84
6.9 COLLECTION, STORAGE, TREATMENT AND DISPOSAL OF WASTES 86
6.9.1 Waste Segregation 86

6.9.2 Collection, Storage and Transport 86
6.9.3 Combined Treatment Facilities 87
6.9.4 Disposal Methods 87
6.9.4.1 Landfill 92
6.9.4.2 Incineration 100
6.9.4.3 Manifest System 103
6.9.4.4 Post Treatment 103
6.9.4.5 Back-Transport 105
6.9.5 Monitoring 105
6.9.6 Record Keeping 110
6.10 LEGISLATION FOR MANAGEMENT OF HAZARDOUS WASTE AND CATEGORISATION OF HAZARDOUS WASTE 113
6.11 HANDLING OF HAZARDOUS CHEMICALS 113
6.12 INDUSTRIAL LOCATION 114
6.13 MANAGEMENT OF INDUSTRIAL SOLID CO-ORDINATION (SPCBs AND LOCAL BODIES) 114
7. BIOMEDICAL WASTE 116
7.1 INTRODUCTION 116
7.1.1 Linkage of Bio-medical Waste Management with Municipal waste management 118
7.2 ASSESSMENT OF CURRENT SITUATION 119
7.2.1 Waste Generation 119
7.2.1.1 Health care Establishments 119
7.2.1.2 Whole town/city 121
7.2.2 Current Practices 122
7.2.3 Allocation of Responsibilities 123
7.3 BASIC ISSUES 123
7.3.1 Management Issues of Bio-medical Waste Management 123
7.3.2 Current Issues in Management of Health Care Waste 123
7.4 LEGAL ASPECTS AND ENVIRONMENTAL CONCERN 124
7.4.1 Biomedical Waste (Management and Handling) Rules, 1998 124
7.4.2 Environmental Concern 125
7.5 WASTE IDENTIFICATION AND WASTE CONTROL PROGRAMME FOR THE HEALTH CARE ESTABLISHMENTS 126

7.5.1 Identification of various components of the waste generated 126
7.5.2 An exercise in Waste Control Programme 126
7.6 WASTE STORAGE 127
7.6.1 Recommended labelling and Colour coding 127
7.6.2 Segregated Storage in separate containers(at the point of generation) 128
7.6.3 Certification 128
7.6.4 Common/Intermediate Storage Area 129
7.6.5 Parking lot for collection vehicles 129
7.7 HANDLING AND TRANSPORATION 129
7.7.1 Collection of Wastes inside the hospital/Health care Establishment 129
7.7.2 Transportation of Segregated Waste inside the premises 130
7.7.3 Collection and Transportation of waste for small units 130
7.7.4 Transportation of Waste Outside 131
7.8 WASTE TREATMENT AND DISPOSAL : THE RULES AND THE AVAILABLE OPTIONS 131
7.8.1 Incineration 132
7.8.2 Autoclave Treatment 132
7.8.3 Hydroclave Treatment 133
7.8.4 Microwave Treatment 133
7.8.5 Chemical Disinfection 134
7.8.6 Sanitary and Secured Landfilling 134
7.8.7 General Waste 135
7.9 COMMON TREATMENT/DISPOSAL FACILITY 136
7.9.1 Establishment of the facility 136
7.9.2 Tie up of health care set ups 137
7.9.3 Private Sector Participation 138
7.10 OPERATION AND MAINTENANCE 138
7.11 OCCUPATIONAL HAZARDS AND SAFETY MEASURES 138
7.11.1 Occupational Hazards 139
7.11.2 Safety measures for the medical and para-medical staff 139
7.11.3 Safety measures for the cleaning and transportation staff 139
7.12 FINANCIAL ASPECTS 140
7.13 TRAINING AND MOTIVATION 140
7.13.1 Training modules for different level of staff 141

7.13.2 Incentives and Motivation 144
7.13.3 Awareness Generation 144
7.14 PLANNING ELEMENTS 144
7.14.1 Planning Inside the Health Care Establishment Premises 145
7.14.2 Planning Inside the Health Care Establishment 147
7.14.3 Relation to Overall Town Planning 147
7.14.4 Examples 148
7.15 MANAGEMENT ASPECTS 150
7.15.1 Organisational set up 151
7.15.2 Administrative and Managerial Aspects 151
7.16 ANIMAL WASTE 153
8. SORTING AND MATERIAL RECOVERY 154
8.1 INTRODUCTION 154
8.2 OBJECTIVES OF SORTING 154
8.3 STAGES OF SORTING 154
8.4 SORTED WASTE STREAMS 155
8.5 SORTING OPERATIONS 155
8.6 CURRENT STATUS 156
8.6.1 Primary and Secondary / Tertiary Sorting 158
8.6.2 Primary Sorting At Source 158
8.6.3 Primary Sorting At the Community Bin (Municipal Bin) 158
8.6.4 Primary Sorting At Landfill 159
8.6.5 Secondary / Tertiary Sorting 159
8.6.6 Occupational Health 159
8.7 TOXICITY RELATED HAZARDS 160
8.7.1 Hazardous Substance Containers 161
8.7.2 Household Batteries and Other Toxic Wastes 161
8.7.3 Infectious Wastes 161
8.8 NON-RECYCLABLE PACKAGING 161
8.9 PROBLEMS AND DESIRABLE CHANGE 162
8.9.1 Long-Term Desirable Change 162
8.10 GUIDELINES FOR SORTING FOR MATERIALS RECOVERY 164
8.10.1 General 164
8.10.2 At the Source 165

8.10.3 At the Community Bin (Municipal Bin)/Waste Storage Depot/ Transfer Station 165
8.10.4 Intermediate Sorting at Central Sorting Facility 168
8.10.5 Sorting at Waste Processing Site 168
8.10.6 Sorting Prior to Landfilling 169

9. STORAGE OF WASTE AT SOURCE 170

9.1 INTRODUCTION 170
9.2 PRESENT SCENARIO 170
9.2.1 No Storage at Source – Waste Deposited on the Streets 170
9.2.2 Storage of waste, wherever practised, does not synchronize with primary collection system 171
9.3 MEASURES TO IMPROVE THE SYSTEM 171
9.3.1 Types of Wastes to be put in the bin meant for food waste and Bio-degradable Waste 171
9.3.2 Types of Recyclable and Other Non-Biodegradable Waste to be kept separately 172
9.3.3 List of Some Domestic Hazardous Waste 172
9.4 STEPS TO BE TAKEN BY URBAN LOCAL BODIES 173
9.4.1 For Storing Household Waste 173
9.4.2 For Storing Waste from Shops/Offices/Institutions/Workshops etc. 176
9.4.3 For Storing Waste from Hotels and Restaurants 177
9.4.4 For Storing Vegetable/Fruit Markets Waste 178
9.4.5 Meat and Fish Markets 179
9.4.6 Street Food Vendors 179
9.4.7 Marriage Halls/Kalyan Mandaps/Community Halls etc. 179
9.4.8 Hospitals/Nursing Homes/Pathological Laboratories/ Health are Centres/Establishments etc. 179
9.4.9 Construction & Demolition Wastes 180
9.4.10 Garden Waste 181
9.5 STORAGE OF RECYCLABLE WASTE 182
9.6 MEASURES TO BE TAKEN BY THE LOCAL BODIES TOWARDS SEGREGATION OF RECYCLABLE WASTE 182
9.7 PROVISION OF LITTER BINS ON THE STREETS, PUBLIC PLACES ETC. 183

9.8	PROVISION OF SPECIAL CONTAINERS FOR STORAGE OF DOMESTIC HAZARDOUS AND TOXIC WASTES	184
10.	**PRIMARY COLLECTION OF WASTE**	187
10.1	INTRODUCTION	187
10.2	PRESENT SCENARIO	187
10.3	MEASURES NECESSARY TO IMPROVE THE SERVICE	187
10.4	STEPS TO BE TAKEN	188
10.5	ARRANGEMENTS TO BE MADE FOR PRIMARY COLLECTION	188
10.6	TOOLS & EQUIPMENT	190
	10.6.1 Hand Carts	190
	10.6.2 Tricycles	191
	10.6.3 Community Bin Carrier	192
10.7	METHODS OF PRIMARY COLLECTION OF WASTE	192
	10.7.1 Door step collection through containerized handcarts	192
	10.7.2 Role of Sweeper	193
	10.7.3 Collection through motorised vehicles	193
	10.7.4 Primary Collection of Waste from Societies/Complexes	193
	10.7.5 Collection of Waste from Slums	194
	10.7.6 Collection at the door in posh residential areas	194
	10.7.7 Collection of duly segregated recyclable/non-bio-degradable waste from Households	194
10.8	ENCOURAGEMENT TO NGO'S/PRIVATE SECTOR	195
10.9	COLLECTION OF WASTE FROM SHOPS AND ESTABLISHMENTS	196
10.10	COLLECTION OF BIO-MEDICAL WASTE	197
10.11	COLLECTION OF HOTEL AND RESTAURANT WASTE	197
10.12	VEGETABLE, FRUIT, MEAT AND FISH MARKETS WASTE	197
10.13	COLLECTION OF GARDEN WASTE	198
10.14	COLLECTION OF WASTE FROM MARRIAGE HALLS/KALYAN MANDAPS/COMMUNITY HALLS ETC.	198
10.15	COLLECTION OF CONSTRUCTION AND DEMOLITION WASTE	198
10.16	DAIRY AND CATTLE-SHED WASTE	199

10.17	COLLECTION OF DOMESTIC HAZARDOUS & TOXIC WASTE	199
11.	**STREET CLEANSING**	200
11.1	INTRODUCTION	200
11.2	SOURCES	200
	11.2.1 Natural Wastes	201
	11.2.2 Road Traffic Wastes	201
	11.2.3 Behavioural Wastes	201
11.3	MANUAL CLEANSING OF STREET AND PUBLIC PLACES	201
	11.3.1 Frequency of Street Cleansing	202
	11.3.1.1 Cleansing of Streets on a daily basis including Sundays & Public Holidays	202
11.4	CLASSIFICATION OF STREETS	204
	11.4.1 Sweeping Methods	205
	11.4.2 Work-norms for Street Sweepers	205
	11.4.3 Working Hours	206
11.5	EQUIPMENT USED FOR STREET SWEEPING	206
	11.5.1 Brooms	206
	11.5.2 Shovels	207
	11.5.3 Container for Transfer of Sweepings	209
	11.5.4 Vehicles and Transfer Facilities	209
	11.5.5 Hand-Carts/Tricycles	211
	11.5.5.1 Specifications for Polyethylene Container to be used in the Hand cart	*214*
	11.5.5.2 Material of Manufacture	*214*
11.6	CLEANSING OF SURFACE DRAINS	214
11.7	REMOVAL OF SILT FROM UNDERGROUND DRAINS/ MANHOLES	216
11.8	MECHANICAL SWEEPING	216
11.9	INSTITUTIONAL ARRANGEMENT FOR MANUAL SWEEPERS	217
11.10	LEGISLATION	218
12.	**WASTE STORAGE DEPOTS**	219
12.1	INTRODUCTION	219
12.2	THE PRESENT SCENARIO	219

12.3 MEASURES TO BE TAKEN TO IMPROVE THE SITUATION 220
12.4 STEPS TO BE TAKEN BY THE LOCAL BODY 222
12.5 OPTIONS 222
12.6 CRITERIA FOR PLACING LARGE SIZE CONTAINERS AT THE WASTE STORAGE DEPOTS 226
12.7 MAINTENANCE OF WASTE STORAGE DEPOTS/ CONTAINERS 227

13. TRANSPORTATION OF WASTE 228

13.1 INTRODUCTION 228
13.2 THE PRESENT SCENARIO 228
13.2.1 Inefficient and unscientific manual loading of waste 228
13.2.2 Irregular Transportation 230
13.2.3 Underutilization of Fleet of Vehicles 231
13.2.4 Open Trucks Cause Nuisance 231
13.2.5 Non-Routing of Vehicles 232
13.2.6 Transportation of Waste from Hotels/Restaurants/Hospitals/ Construction Site etc. 232
13.3 MEASURES TO BE TAKEN TO IMPROVE THE SYSTEM 233
13.4 STEPS TO BE TAKEN TO MEET THE ABOVE OBJECTIVES 233
13.4.1 Domestic/Trade/Institutional Waste 233
13.4.2 Routing of Vehicles 234
13.4.3 Use of Vehicles in Two Shifts 234
13.4.4 Type of Vehicles to be used 234
13.4.5 Bio-Medical Waste from Hospitals/Nursing Homes/Health Care Establishments etc. 237
13.4.6 Transportation of Waste from Hotels & Restaurants 237
13.4.7 Transportation of Construction Waste and Debris 238
13.4.8 Transportation of Waste from Narrow Lanes 239
13.5 SETTING UP OF TRANSFER STATION 239
13.6 LIFTING OF WASTE FROM THE TRANSFER STATION 239
13.7 WORKSHOP FACILITY FOR VEHICLE MAINTENANCE 239
13.8 FLEET OF VEHICLES TO BE MAINTAINED 241
13.9 PARKING OF WORKSHOP VEHICLES 242

14. COMPOSTING 243

14.1 INTRODUCTION 243

14.2 PRINCIPLES OF COMPOSTING – MANUAL AND MECHANISED METHODS 243

14.3 INDORE & BANGALORE METHODS OF COMPOSTING 244

14.3.1 Bangalore Method 244

14.3.2 Indore Method 244

14.3.3 Comparison of the Methods 244

14.3.4 Windrow Composting 245

14.4 FACTORS AFFECTING THE COMPOSTING PROCESS 246

14.4.1 Organisms 246

14.4.2 Use of Cultures 247

14.4.3 Moisture 247

14.4.4 Temperature 247

14.4.5 C/N Ratio 248

14.4.6 Aeration 250

14.4.7 Addition of sewage and sewage sludge 250

14.5 CONTROL OF COMPOSTING PROCESS 251

14.5.1 Properties of Compost 252

14.6 MECHANICAL COMPOSTING 253

14.6.1 Unit Processes 253

14.6.2 Experience in India 257

14.6.3 Composting plants for Indian Municipal Solid Waste 258

14.6.3.1 Assessment & Development of Market 258

14.6.3.2 Selection of Site 258

14.6.3.3 Pilot Studies 258

14.6.3.4 Flowsheet 259

14.6.3.5 Environmental Control 260

15. ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE 262

15.1 INTRODUCTION 262

15.2 BASIC TECHNIQUES OF ENERGY RECOVERY FROM MSW 262

15.2.1. Parameters affecting Energy Recovery 263

15.2.2. Assessment of Energy Recovery Potential 265

15.3 TECHNOLOGICAL OPTIONS 266

15.3.1 Anaerobic Digestion(AD) 266

15.3.1.1 Main Steps in Anaerobic Treatment of MSW 268

15.3.1.2 Different Designs and Configurations of AD Systems 268

15.3.2 Landfill Gas Recovery 270

15.3.2.1 Selection of Existing Landfill Sites for Gas Recovery 276

15.3.2.2 Assessment of Gas Production Potential 276

15.3.3 Incineration 279

15.3.3.1 Different types of Incineration Plants 280

15.3.3.2 Indian scenario for Adoption of Incineration Technology 285

15.3.4 Pyrolysis/Gasification 286

15.3.4.1 Different Types of Pyrolysis/Gasification Systems 287

15.3.4.2 Other Emerging Processes 290

15.3.5 Advantages and Disadvantages of different Technological Options 291

15.3.6 Land Requirements 293

15.4 UTILIZATION OF BIOGAS/LANDFILL GAS 294

15.4.1 Local Gas Use 294

15.4.2 Pipeline Injection 295

15.4.3 Electricity Generation 295

15.4.4 Purification of Biogas 297

15.4.4.1 Chemical Processes 297

15.4.4.2 Bio-Chemical Processes 297

15.4.4.3 Summary of Gas Cleaning Methods 298

15.5 ENVIRONMENTAL MANAGEMENT OF WASTE-TO-ENERGY PROJECTS 299

15.5.1 Environmental Pollution Control(EFC) Measures for Incineration Plants 299

15.5.2 EPC Measures for Ananerobic Digestion Plants 303

15.5.3 General Environmental Concerns and Control Measures 303

15.6 PLANNING AND EXECUTION OF WASTE-TO-ENERGY PROJECTS 303

15.6.1 Basic Factors in Planning and Execution 305

15.6.1.1 Cost of Collection & Transportation of Waste 305

15.6.1.2 Scale of Treatment 305

15.6.1.3 Local Conditions/Existing Waste Management Practices 306

15.6.1.4 Physical and Chemical Characteristics of the Waste 306
15.6.1.5 Seasonal Fluctuations in Wastes Quantity & Quality 307
15.6.1.6 Treatment/Disposal of Rejects/Effluents 307
15.6.1.7 Energy End Use 308
15.6.1.8 Capital and Recurring Costs 308
15.6.1.9 Environmental Impact 308
15.6.2 Suggested Scope of Feasibility Studies 309
15.6.2.1 Quantity of Municipal Solid Waste Generated per day 309
15.6.2.2 Current Mechanism for Collection/Transportation 309
15.6.2.3 Physical & Chemical Characteristics of Collected Waste 309
15.6.2.4 Present Mode of Disposal 309
15.6.2.5 Provisions in the Existing System 309
15.6.2.6 Commitments/Arrangements of concerned Municipality with Private Parties regarding Waste Collection/Disposal, if any 310
15.6.2.7 Details about the proposed scheme of Energy Recovery 310
15.6.2.8 Environmental Impact Assessment Analysis of the Selected Option 310
15.6.2.9 Energy End Users Revenue Generation 310
15.6.2.10 Cost Estimates 310
15.7 CASE STUDIES 310
15.8 CONCLUSIONS 310
16. EMERGING PROCESSING TECHNOLOGIES 312
16.1 INTRODUCTION 312
16.2 VERMICOMPOSTING 312
16.3 BIOGAS FROM MUNICIPAL SOLID WASTES 314
16.4 CONVERSION OF SOLID WASTES TO PROTEIN 314
16.5 ALCOHOL FERMENTATION 315
16.6 PYROLYSIS 315
16.6.1 Plasma Arc Technology/Plasma Pyrolysis Vitrification (PPV) 317
16.7 REFUSE DERIVED FUEL 317
16.8 HYDROPULPING 320
16.9 SLURRY CARB PROCESS 320

16.10 TREATMENT FOR RECOVERY OF USEFUL PRODUCTS 320
16.11 SUMMARY 323

17. LANDFILLS 325

17.1 INTRODUCTION 325
17.1.1 Definitions 325
17.1.2 Landfilling of Municipal Solid Waste 325
17.2 ENVIRONMENTAL IMPACT AND ITS MINIMISATION 329
17.3 ESSENTIAL COMPONENTS 329
17.4 SITE SELECTION 330
17.4.1 Locational Criteria 330
17.4.2 Search Area 332
17.4.3 Development of A List of Potential Sites 332
17.4.4 Data Collection 333
17.4.5 Site-Walk-Over and Establishment of Ground Truths 334
17.4.6 Preliminary Boreholes and Geophysical Investigation 334
17.4.7 Assessment of Public Reaction 334
17.4.8 Selection of Few Best-Ranked Sites 335
17.4.9 Environmental Impact Assessment 336
17.4.10 Final Site Selection 336
17.5 SITE INVESTIGATION AND SITE CHARACTERISATION 336
17.5.1 Subsoil Investigation 339
17.5.2 Ground Water/Hydrogeological Investigation 339
17.5.3 Topographical Investigation 340
17.5.4 Hydrological Investigation 340
17.5.5 Geological Investigation and Seismic Investigation 340
17.5.6 Environmental Investigation 340
17.5.7 Traffic Investigation 341
17.5.8 Waste Characterisation 341
17.5.9 Leachate Investigation 341
17.6 LANDFILL PLANNING AND DESIGN 342
17.6.1 Design Life 342
17.6.2 Waste Volume and Landfill Capacity 342
17.6.3 Landfill Layout 343
17.6.4 Landfill Section 343

	17.6.5	Phased Operation	346
	17.6.6	Estimation of Leachate Quality and Quantity	348
		17.6.6.1 *Leachate Quality*	350
		17.6.6.2 *Leachate Quantity*	352
	17.6.7	Liner System	354
	17.6.8	Leachate Drainage, Collection and Removal	358
	17.6.9	Leachate Management	361
	17.6.10	Estimation of Landfill Gas Quality and Quantity	362
	17.6.11	Landfill Gas Management	364
	17.6.12	Final Cover System	364
	17.6.13	Surface Water Drainage System	366
	17.6.14	Slope Stability Aspects and Seismic Aspects	369
	17.6.15	Materials Balance	371
	17.6.16	Site Infrastructure	371
	17.6.17	Landfill Equipment	372
	17.6.18	Design of Environmental Monitoring System	373
	17.6.19	Closure and Post-Closure Maintenance Plan	376
	17.6.20	Waste Acceptance Criteria	376
17.7	DESIGN AND CONSTRUCTION OF LANDFILL LINERS		377
	17.7.1	Compacted Clays and Amended Soils	378
		17.7.1.1 *Specifications*	379
		17.7.1.2 *Design Process*	379
		17.7.1.3 *Laboratory Studies*	380
		17.7.1.4 *Field Trail Test Pads*	382
		17.7.1.5 *Construction Aspects*	382
		17.7.1.6 *Construction Control*	385
	17.7.2	Geomembranes	385
		17.7.2.1 *Specifications*	385
		17.7.2.2 *Design Aspects*	387
		17.7.2.3 *Construction/Installation of Geomembranes*	387
		17.7.2.4 *Quality Control Before and During Geomembrane Installation*	388
	17.7.3	Drainage Blanket	389

17.8 CONSTRUCTION AND OPERATIONAL PRACTICE 389
17.8.1 Site Development 390
17.8.2 Site Procedures 390
17.8.2.1 Record Keeping 390
17.8.2.2 Waste Inspection Procedure 391
17.8.3 Phase Development 392
17.8.4 Phase Operation 392
17.8.4.1 Daily Waste Filling Plan and Demarcation at Site 393
17.8.4.2 Waste Discharge and Inspection 393
17.8.4.3 Waste Placement (Spreading) 394
17.8.4.4 Waste Compaction 394
17.8.4.5 Daily Cover 396
17.8.4.6 Pollution Prevention During Operation 397
17.8.4.7 Landfill Fire Management 399
17.8.4.8 Landfill Safety Aspects 400
17.8.5 Phase Closure 400
17.8.6 Landfill Closure 401
17.9 POST-CLOSURE STABILISATION, OPERATION AND CARE 402
17.9.1 Long-Term Vegetative Stabilisation 402
17.9.2 Operation After Closure 403
17.9.3 Landfill Monitoring 403
17.9.4 Periodic Inspection and Maintenance 405
17.10 LANDFILL QUALITY ASSURANCE AND QUALITY CONTROL 406
17.11 LANDFILLING COSTS 407
17.12 MANPOWER REQUIREMENTS 408
17.13 TYPICAL EXAMPLE (PRELIMINARY DESIGN) 409
17.14 REMEDIATION OF OLD LANDFILL SITES 409
18. COMMUNITY PARTICIPATION 410
18.1 INTRODUCTION 410
18.2 STRATEGY OF COMMUNITY PARTICIPATION 410
18.2.1 Identification of groups of people to be addressed 410
18.2.1.1 Residential Areas 410
18.2.1.2 Market / Commercial Areas/Offices/Bank etc. 411

18.2.2 Identification of the areas in SWM where community participation is essential 411
18.2.2.1 Peoples participation is essential in following areas 411
18.2.3 Reach the community 412
18.2.3.1 Identification of problems 412
18.2.3.2 Finding out optional solution 412
18.2.3.3 Consult community on options available 412
18.2.3.4 Workout the strategy of implementation 413
18.3 SYSTEM OF WASTE MANAGEMENT TO BE ADOPTED 413
18.3.1 Public information, Education, Communication programs(IEC) 413
18.4 MEASURES TO BE TAKEN TO BRING ABOUT CHANGE IN PUBLIC BEHAVIOR 414
18.4.1 Promote "Reduce, Re-use and Re-cycle(R-R-R)" of waste 414
18.4.2 Promote Public Participation in SWM systems adopted 415
18.4.3 Provide Information Hot-line 416
18.4.4 Public Education 416
18.4.4.1 Group Education 416
18.4.4.2 Mass Education 416
18.5 ENFORCEMENT 420
19. INSTITUTIONAL ASPECTS & CAPACITY BUILDING 421
19.1 INTRODUCTION 421
19.2 DECENTRALIZATION OF ADMINISTRATION 421
19.2.1 Ward Level Administration 422
19.2.2 Zonal Administration 422
19.2.3 City Level Administration 423
19.3 DELEGATION OF POWERS 423
19.4 ORGANIZATIONAL SET UP/PUBLIC HEALTH ENGINEERS 423
19.4.1 Towns below 1,00,000 population 424
19.4.2 Cities between 1 and 2 lacs population 424
19.4.3 Cities having population between 2 and 5 lacs 424
19.4.4 Cities having population between 5 and 20 lacs 425
19.4.5 Cities having population between 20 and 50 lacs 425
19.4.6 Cities above 50 lacs population 425

19.5 HUMAN RESOURCES DEVELOPMENT 426

19.5.1 Training 426

19.5.1.1 Special Training to Unqualified Staff 426

19.5.1.2 Refresher Courses for all Levels of Staff 426

19.5.1.3 Exposure to Municipal Commissioner/Chief Executives 426

19.5.1.4 Exposure to Elected Members 427

19.5.1.5 Design SWM Courses 427

19.5.2 Promotional Opportunities 427

19.6 WORK NORMS 427

19.6.1 Norms of Work for Street Sweepers 428

19.7 THE ENTIRE ADMINISTRATION OF SWM DEPARTMENT TO BE UNDER ONE UMBRELLA 429

19.8 INTER-DEPARTMENTAL CO-ORDINATION 430

19.9 ENCOURAGEMENT TO NGOs AND WASTE COLLECTOR COOPERATIVES 430

19.10 VOLUNTARY ORGANISATION/NGO/PRIVATE SECTOR PARTICIPATION 431

19.11 INCENTIVES TO THE PRIVATE SECTOR 431

19.12 LEVY OF ADMINISTRATIVE CHARGES 431

19.13 MOBILE SANITATION COURTS 432

19.14 DOCUMENTATION OF BEST PRACTICES 432

19.15 REDRESSEL OF PUBLIC GRIEVANCES 432

20. PROSPECTS OF PRIVATE SECTOR PARTICIPATION 433

20.1 INTRODUCTION 433

20.2 PRESENT SCENARIO 433

20.3 MEASURES TO BE TAKEN BY LOCAL BODIES 433

20.4 AREA WHERE PRIVATIZATION CAN BE ATTEMPTED 434

20.5 METHOD OF PRIVATE SECTOR INVOLVEMENT IN DOORSTEP COLLECTION OF VARIETY OF WASTES 435

20.6 INCENTIVES TO PRIVATE SECTOR 435

20.7 SOME EXAMPLES 436

21. ECONOMIC AND FINANCIAL CONSIDERATIONS 438

21.1 INTRODUCTION 438

21.2 PRESENT FINANCIAL PROVISION 439

21.3 EXPENDITURE AND COST OF SWM 442

21.4 PROJECT LIFE CYCLE ANALYSIS 444

21.5 NON-MARKET EXTERNALITIES IN SWM 445

21.6 LACK OF FINANCIAL PLANNING FOR SWM 445

21.7 FINANCIAL MANAGEMENT PLAN 446

21.7.1 Principle Elements of the Financial Management Plan 446

21.7.2 Determination of Tax/Cess Rates 447

21.7.2.1 Determination of the Rate of SWM Tax 448

21.7.3 Solid Waste Management Benefit Tax 449

21.8 ACTION PLAN 449

21.9 ADDITIONAL SOURCES OF FUNDS 451

22. ENVIRONMENTAL AND HEALTH IMPACT ASSESSMENT 454

22.1 INTRODUCTION 454

22.1.1 Need for Environmental and Health Impact 455

22.2 THE SIGNIFICANCE OF ENVIRONMENTAL AND HEALTH IMPACT ASSESSMENT(EHIA) 457

22.2.1 Identification, Interpretation & Management of EHIA 459

22.3 TYPES OF ENVIRONMENTAL AND HEALTH HAZARDS 461

22.4 ENVIRONMENTAL AND HEALTH HAZARDS IDENTIFICATION 463

22.5 INITIAL ENVIRONMENTAL AND HEALTH EXAMINATION (IEHE) 464

22.5.1 Vulnerable Communities 466

22.5.2 Environmental Factors 468

22.5.3 Responsibilities of Protection Agencies 469

22.6 PROJECTS REQUIRING DETAILED ENVIRONMENTAL AND HEALTH IMPACT ASSESSMENT 470

22.6.1 Components of EHIA 472

22.6.2 Scope 472

22.6.3 Steps involved in EHIA Studies 473

22.6.4 Model Terms of Reference(s) for EHIA 473

22.7 EHIA STATEMENT 476

22.8 ENVIRONMENT AND HEALTH RISK MANAGEMENT ` 476

22.8.1 Environmental Management Plan 476
22.8.2 Health Risk Management 479
22.8.3 Risk to Human Life and Property 481
22.9 PUBLIC INFORMATION AND PARTICIPATION FOR EHIA 481
22.9.1 Awareness of public on the various aspects of environment and health surveillance 481
22.10 FINANCIAL ASPECTS 482
22.10.1 Suggested Investment 482
23. MANAGEMENT INFORMATION SYSTEM 483
23.1 INTRODUCTION 483
23.1.1 Objective 483
23.1.2 Need 483
23.2 GENERAL INFORMATION DATA 484
23.2.1 Salient Features of the City/Ward 484
23.2.2 General Information on SWM 485
23.2.2.1 Waste Generation 485
23.2.2.2 Staff Position 485
23.2.2.3 Waste Storage Depots 485
23.2.2.4 Transportation 486
23.2.2.5 Composition of Waste 486
23.2.2.7 Computerisation 487
23.2.2.8 Financial Aspects 488
23.3 Technical 488
23.3.1 Primary Collection 488
23.3.1.1 Population and Composition of Waste 488
23.3.1.2 Source of Generation 488
23.3.1.3 Manpower and Implements 489
23.3.1.4 Monitoring of Primary Collection Services 489
23.3.2 Secondary Collection 492
23.3.2.1 Transfer Stations 492
23.3.2.2 Transportation 493
23.3.3 Disposal 498
23.3.3.1 Options 498
23.3.3.2 Daily/Weekly Records 500

23.4 PROJECT MONITORING 501
23.5 PUBLIC AWARENESS & TRAINING 501
23.5.1 Public Awareness 501
23.5.2 Training to Ward Councilors 501
23.5.3 Partnership Role for Public Awareness 501
23.5.4 Mode of Implementing Public Awareness Programme 501
23.5.5 Public Participation 502
23.6 INSTITUTIONAL ORGANIZATION 502
23.7 POLICY GUIDELINES 502
23.8 FINANCIAL AND ECONOMIC ASPECT 503
23.9 LEGAL ASPECTS 503
23.10 COMPLAINTS REDRESSAL 503
24 LEGAL ASPECTS 504
24.1 INTRODUCTION 504
24.2 PRESENT SCENARIO 504
24.3 PROPOSED LEGAL PROVISIONS 506
24.3.1 Prohibition against littering the street or deposition of solid waste on the streets, open defecation etc. 506
24.3.2 Duty of occupiers of premises to store solid waste at source of generation 506
24.3.3 Duty of occupier not to mix recyclable/non-bio-degradable waste and domestic hazardous waste with food waste etc. 506
24.3.4 Duty of Societies/Associations/Management of commercial complexes to clean their premises and to provide community bins 506
24.3.5 Community Bins to be kept in good condition 507
24.3.6 Duty of occupiers to deposit solid waste in community bins 507
24.3.7 Duty of local body to provide and maintain "Waste Storage Depots" 507
24.3.8 Duty of occupier of households/shops/establishment to hand over the recyclable material/non-bio-degradable waste to the waste collectors/waste purchasers/recyclers. 507
24.3.9 Duty of occupier of households, shops and establishments to deposit domestic hazardous/toxic waste in special bins 508

24.3.10 Duty of local bodies to collect waste from community bins and to deposit it at Waste Storage Depots for onward transport 508

24.3.11 Duty of local bodies to clean all public streets, open public spaces and slum areas 508

24.3.12 Duty of local body to transport the waste stored at the waste storage depots regularly. 508 508

24.3.13 Duty of local body to arrange for processing of food/ bio-degradable waste through appropriate technology and disposal of Rejects 508

24.3.14 Prohibition against deposition of building rubbish 508

24.3.15 Prohibition on disposal of carcasses etc. 509

24.3.16 Punishment for littering on streets 509

24.4 SOME EXAMPLES OF ENFORCEMENT WHICH HAVE GIVEN SALUTARY EFFECT 509

25. POLICY GUIDELINES 511

25.1 INTRODUCTION 511

25.2 POLICY FRAME WORK 512

25.3 ISSUES 512

25.4 MEASURES TO BE TAKEN 513

25.4.1 The Central Government 513

25.4.2 The State Government 514

25.4.2.1 Provide Legal Frame Work 514

25.4.2.2 Promote Financial Health of the Urban Local Bodies To meet obligatory duties 514

25.4.2.3 Grant of Land for Treatment Facility and Disposal of Waste 515

25.4.2.4 Identification of suitable land for Treatment and Disposal of Municipal Solid Waste in city's Development Master Plan 515

25.4.2.5 Permit allotment of land to private sector for Setting up treatment facilities and landfill sites For waste disposal 515

25.4.2.6 Payment of Tipping Charges 516

25.4.2.7 Promote Recycling Industry 516

25.4.2.8 Provide Tax Benefits *516*
25.4.2.9 Promote Use of Compost *516*
25.4.2.10 Promote Energy Recovery, Power Generation etc. From MSW *516*
25.4.2.11 Encourage Private Sector Participation *517*
25.4.2.12 Develop IEC Material *517*
25.4.3 The Urban Local Bodies 517
25.4.3.1 Provision of Daily Service *517*
25.4.3.2 Segregation and Storage of Waste at Source *517*
25.4.3.3 Abolish open waste storage depots and other Inefficient waste storage devices *518*
25.4.3.4 Cost Recovery *518*
25.4.3.5 Levy of Sanitation tax to meet & cost of SWM services *518*
25.4.3.6 Public Private Partnership in SWM Services *518*
25.4.3.7 Private Sector Participation *518*
25.4.3.8 Provision of SWM Services in slums *519*
25.4.3.9 Allotment adequate funds for capital and revenue Expenditure *519*
25.4.3.10 Identification and allotment of suitable lands For treatment and waste disposal *519*
25.4.3.11 Human Resources Development *519*
25.4.3.12 Public Grievances Redressal Mechanism *519*
25.4.3.13 Enforcements *520*
25.4.3.14 Welfare of the Staff *520*
25.5 POLICY ORDERS ISSUED BY SOME STATES 520
25.6 MUNICIPAL WASTE (MANAGEMENT & HANDLING) RULES 520
26. PREPARATION OF A MUNICIPAL SOLID WASTE MANAGEMENT PLAN 521
26.1 THE PLANNING PROCESS : DEFINITION 521
26.2 DESIGN PERIOD 521
26.3 POPULATION FORECAST 522
26.4 BASIC PLANNING MODEL 522
26.4.1 Initial Planning 523

26.4.2 Problem Redefinition 523
26.4.3 Objectives and Consideration of Alternative Actions 523
26.4.4 Emerging Alternatives and Decisions 523
26.4.5 Plan Establishment 525
26.5 COORDINATION 525
26.6 PLAN OUTLINE 526

ANNEXURES

Annexure No.

A Conversion Factors 533
B List of Indian Standards relating to Solid Waste Management 536
1.1 Municipal Wastes (Management & Handling Rules, 1999) 538
5.1 Environment (Protection) Act, 1986 558
5.2 Guidelines for Financial Assistance for improvement of existing Slaughter Houses and establishment of Carcass & By-Product Utilisation Centres 584
5.2A Objectives for improvement of Slaughter Houses and Carcass & By-Product Utilisation Centres 587
5.2B Pattern of Funding for improvement of Slaughter Houses 588
5.2C Pattern of Funding for Carcass & By-Product Utilisation Centre 592
5.2D Proforma for Submitting the Proposals for Slaughter Houses & Carcass Utilisation Centres 594
5.3 Draft Guidelines for Sanitation in Slaughter Houses 597
6.1 List of Processes Generating Hazardous Wastes 605
6.2 Categories of Industries to be restricted for their operation in Non-Conforming areas 611
7.1 Solid Wastes – Hospitals – Guidelines for Management 613
7.2 Bio-Medical Waste (Management & Handling) Rules, 1998 618
7.3 List of States where Prescribed Authority has been set up for supervising the Implementation of the Bio-Medical Waste (Management & Handling) Rules 629
7.4 Comparison of Treatment Technologies for “Bio-Medical Waste” 630
7.5 Schematic of pit for deep burial of Cate Goryi-Bio-Medical Waste (based on Bio-Medical Waste Management Handling Rules) 632
12.1 The Specification for Construction of Waste Storage Depot 633
12.2 General Specification of 7 cu.mt. capacity Garbage Containers to be handled by 7 cu.mt. D.P. units 634

13.1	Hydraulic Vehicle Inspection Schedule	639
13.2	Schedule of Maintenance of Trucks & Vehicles	644
13.3	Minimum equipment/tools required for workshop to Maintain a fleet of up to 50 Vehicles	653
15.1	Waste to Energy Case Studies	654
15.2	Ministry of Non-Conventional Energy Sources – Salient Features of Incentives given	660
17.1	Estimation of Landfill Capacity, Landfill Height, Landfill Area	672
17.2	Typical Example (Preliminary Design)	675
17.3	Estimation of Landfill Cost based on Preliminary Design	687
19.1	Typical Organizational Chart for a activity of 30 lacs Population	691
19.2	Brief Course Content for Training to various Levels of Staff/Officers.	694
20.1	Tamil Nadu Contract Labour (Regulation & Abolition) Rules, 1975 – Government Order for abolition of Contract Labour System in SWM – Exemption to Corporation of Chennai	696
21.1(A)	Salient Features of Ministry of Agriculture Guidelines for Recovery of Compost from Urban/Municipal Waste	699
21.1(B)	HUDCO's Financing	700
21.1(C)	An Example : Financing Hospital Waste Management Schemes by HUDCO	702
22.1	Impact Identification Network for Collection System	704
22.2	Impact Identification Network for Disposal System	705
23.1(a)	Daily Monitoring on Collection of Waste from Waste Storage Depot	706
23.1(b)	Primary Collection Operation Summary Table	707
23.2(a)	Monitoring of Transfer Stations Operations (Entry Record Sheet)	708
23.2(b)	Record of Transfer of Waste from Transfer Stations to Disposal Site	709
23.3(a)	Vehicle Movement Monitoring	710
23.3(b)	Vehicle Utility Monitoring	711
23.3(c)	Monitoring Fuel Consumption	712
23.3(d)	Drivers Attendance Monitoring	713
23.3(e)	Vehicle Repair Report	714
23.3(f)	Monitoring Cost of Operations	715
23.4(a)	Daily Waste Disposal Record Sheet for Zone	716
23.4(b)	Monitoring Waste Disposal from all Zones/Divisions	717

23.4(c)	Monthly Record Sheet of Waste Disposal	718
23.4(d)	Equipment Performance Report	719
23.4(e)	Carbon Utility Report	720
23.4(f)	Operating Cost Summary Table	721
23.4(g)	Disposal Cost Summary	722
23.4(h)	Waste Processing Report	723
23.5(a)	Project Information Report	724
23.5(b)	Project Monitoring Report (Name of the Project/Value of the Project)	725
23.6(a)	Financial and Economical Information – Revenue Receipts	726
23.6(b)	Revenue Expenditure	727
23.6(c)	Capital Receipts	728
23.7(a)	Monitoring of Court Cases	729
23.7(b)	Enforcement Measures	730
25.1	Policy Orders issued by State Govts to promote Waste-to-Energy Projects	731
26.1	Population Forecast Methods	744
26.2	Estimation of Future Population (Example)	747
	BIBLIOGRAPHY	753

CHAPTER 1
INTRODUCTION

1.1 PREAMBLE

Over the years, there has been a continuous migration of people from rural and semi-urban areas to towns and cities. The proportion of population residing in urban areas has increased from 10.84% in 1901 to 25.70% in 1991. The number of class I cities has increased from 212 to 300 during 1981 to 1991, while class II cities have increased from 270 to 345 during the same period. The increase in the population in class I cities is very high as compared to that in class II cities. The uncontrolled growth in urban areas has left many Indian cities deficient in infrastructural services such as water supply, sewerage and municipal solid waste management.

Most urban areas in the country are plagued by acute problems related to solid waste. Due to lack of serious efforts by town/city authorities, garbage and its management has become a tenacious problem and this notwithstanding the fact that the largest part of municipal expenditure is allotted to it. It is not uncommon to find 30-50% of staff and resources being utilized by Urban Local Bodies for these operations. Despite this, there has been a progressive decline in the standard of services with respect to collection and disposal of municipal solid waste including hospital and industrial wastes, as well as measures for ensuring adequacy of environmental sanitation and public hygiene. In many cities nearly half of solid waste generated remains unattended, giving rise to insanitary conditions especially in densely populated slums which in turn results in an increase in morbidity especially due to microbial and parasitic infections and infestations in all segments of population, with the urban slum dwellers and the waste handlers being the worst affected.

Solid Waste Management is a part of public health and sanitation, and according to the Indian Constitution, falls within the purview of the State list. Since this activity is non-exclusive, non-rivaled and essential, the responsibility for providing the service lies within the public domain. The activity being of a local nature is entrusted to the Urban Local Bodies. The Urban Local Body undertakes the task of solid waste service delivery, with its own staff, equipment and funds. In a few cases, part of the said work is contracted out to private enterprises.

There has been no major effort to create community awareness either about the likely perils due to poor waste management or the simple steps that every citizen can take which will help in reducing waste generation and promote effective management of solid waste generated. The degree of community sensitization and public awareness is low. There is no system of segregation of organic, inorganic and recyclable wastes at household level. Door to door collection is not practiced in most of the cities.

It is estimated that the total solid waste generated by 300 million people living in urban India is 38 million tonnes per year. The collection and disposal of municipal solid waste is one of the pressing problems of city life, which has assumed great importance in the recent past. With the growing urbanization as a result of planned economic growth and industrialization, problems are becoming acute and call for immediate and concerted action. The proper disposal of urban waste is not only absolutely necessary for the preservation and improvement of public health but it has an immense potential for resource recovery.

It is estimated that about 1,00,000 MT of Municipal Solid Waste is generated daily in the country. Per capita waste generation in major cities ranges from 0.20 Kg to 0.6 Kg. Generally the collection efficiency ranges between 70 to 90% in major metro cities whereas in several smaller cities the collection efficiency is below 50%. It is also estimated that the Urban Local Bodies spend about Rs.500 to Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste. Landfill sites have not yet been identified by many municipalities and in several municipalities, the landfill sites have been exhausted and the respective local bodies do not have resources to acquire new land. Due to lack of disposal sites, even the collection efficiency gets affected.

Very few Urban Local Bodies in the country have prepared long term plans for effective Solid Waste Management in their respective cities. For obtaining a long term economic solution, planning of the system on long-term sustainable basis is very essential.

The Ministry of Environment & Forests, Government of India have notified Draft of “Municipal Waste (Management & Handling) Rules, 1999” on 27th September, 1999. The notification is given as per Annexure 1.1.

1.2 PROBLEMS BEING FACED BY URBAN LOCAL BODIES

Barring a few progressive municipal corporations in the country, all other local bodies suffer due to non-availability of adequate expertise and experience; thereby the solid waste is not properly handled resulting into creation of environmental pollution and health hazards. As mentioned earlier, these local bodies lack technical, managerial, administrative, financial resources, adequate institutional arrangements. Similarly Defence, Railways, CPWD and several Government of India Organizations/Undertakings having large establishments in the cities and towns lack the technical knowhow of managing urban solid waste. It is, therefore, very necessary to provide proper guidance in the Urban Local Bodies/Government Agencies/Establishments referred above, to make them efficient in managing the solid waste generated in their respective areas/cities/towns.

1.3 NEED FOR A MANUAL ON SOLID WASTE MANAGEMENT

Preparation of the Manual on Municipal Solid Waste Management is mainly to assist the personnel involved in managing the solid waste generated in the cities/towns of the country.

The purpose of the Manual is to create:

- An understanding that municipal solid waste management is part of a broader urbanisation problem;
- An awareness of need for competent management of municipal solid waste in urban areas;
- An understanding of various systems available for collection, transportation, recycling, resource recovery and disposals;
- An approach to preparing municipal solid waste management plans in the light of the potential problems and issues which may become apparent during project development; and
- To provide operational guidelines for the efficient municipal solid waste management systems.

1.4 CONSTITUTION OF THE EXPERT COMMITTEE AND METHODOLOGY ADOPTED

With a view to assist and guide the Urban Local Bodies for managing the solid waste in an efficient manner, the Ministry of Urban Development, Government of India constituted an Expert Committee in February, 1998 by drawing experts from various Academic, Research Institutions, Central Ministries/Departments and Urban Local Bodies, to prepare a ***Manual on "Municipal Solid Waste Management"***.

The Committee after a series of deliberations decided to include all the aspects of municipal solid waste in the Manual such as Composition and Quantity of Solid Waste, Bio-Medical Waste, Storage of Waste at Source, Primary Collection of Waste, Transportation of Waste, Composting, Energy Recovery from Municipal Solid Waste, Emerging Processing Technologies, Landfills, Community Participation, Institutional Aspects and Capacity Building, Prospects of Private Sector Participation, Economic and Financial Considerations, Environmental and Health Impact Assessment, Legal Aspects etc. and to give exhaustive details of waste processing and disposal methods.

The various approaches suggested in different Chapters contained in the Manual will assist the policy & decision makers, planners, managers and technical personnel involved in solid waste management activities in safe and hygienic handling & disposal of municipal solid waste generated in the urban areas in the country.

CHAPTER 2

PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT

2.1 INTRODUCTION

Management of municipal solid waste involves (a) development of an insight into the impact of waste generation, collection, transportation and disposal methods adopted by a society on the environment and (b) adoption of new methods to reduce this impact.

2.1.1 Solid Waste Generation

An indication of how and where solid wastes are generated is depicted in a simplified form in Fig. 2.1. Both technological processes and consumptive processes result in the formation of solid wastes. Solid waste is generated, in the beginning, with the recovery of raw materials and thereafter at every step in the technological process as the raw material is converted to a product for consumption. Fig. 2.2 shows generation of solid waste during technological processes involving mining, manufacturing and packaging.

The process of consumption of products results in the formation of solid waste in urban areas as shown in Fig. 2.3. In addition, other processes such as street cleaning, park cleaning, waste-water treatment, air pollution control measures etc. also produce solid waste in urban areas.

A society receives energy and raw material as inputs from the environment and gives solid waste as output to the environment as shown in Fig. 2.1. In the long-term perspective, such an input-output imbalance degrades the environment.

2.1.2 Environmental Impact of Solid Waste Disposal on Land

When solid waste is disposed off on land in open dumps or in improperly designed landfills (e.g. in low lying areas), it causes the following impact on the environment.

(a) ground water contamination by the leachate generated by the waste dump

(b) surface water contamination by the run-off from the waste dump

(c) bad odour, pests, rodents and wind-blown litter in and around the waste dump

(d) generation of inflammable gas (e.g. methane) within the waste dump

(e) bird menace above the waste dump which affects flight of aircraft

(f) fires within the waste dump

(g) erosion and stability problems relating to slopes of the waste dump

(h) epidemics through stray animals

(i) acidity to surrounding soil and

(j) release of green house gas

2.1.3 Objective of Solid Waste Management

The objective of solid waste management is to reduce the quantity of solid waste disposed off on land by recovery of materials and energy from solid waste as depicted in Fig. 2.4. This in turn results in lesser requirement of raw material and energy as inputs for technological processes.

A simplified flow chart showing how waste reduction can be achieved for household waste is shown in Fig. 2.5. Such techniques and management programs have to be applied to each and every solid waste generating activity in a society to achieve overall minimisation of solid waste.

2.2 PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT

Municipal Solid Waste Management involves the application of principle of Integrated Solid Waste Management (ISWM) to municipal waste. ISWM is the application of suitable techniques, technologies and management programs covering all types of solid wastes from all sources to achieve the twin objectives of (a) waste reduction and (b) effective management of waste still produced after waste reduction.

2.2.1 Waste Reduction

It is now well recognised that sustainable development can only be achieved if society in general, and industry in particular, produces 'more with less' i.e. more goods and services with less use of the world's resources (raw materials

and energy) and less pollution and waste. Production as well as product changes have been introduced in many countries, using internal recycling of materials or on-site energy recovery, as part of solid waste minimisation schemes.

2.2.2 Effective Management of Solid Waste

Effective solid management systems are needed to ensure better human health and safety. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically sustainable.

- Environmentally sustainable: It must reduce, as much as possible, the environmental impacts of waste management.
- Economically sustainable: It must operate at a cost acceptable to community.

Clearly it is difficult to minimise the two variables, cost and environmental impact, simultaneously. There will always be a trade off. The balance that needs to be struck is to reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost.

An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach i.e. it deals with all types of solid waste materials and all sources of solid waste (Fig. 2.6). A multi-material, multi-source management approach is usually effective in environmental and economic terms than a material specific and source specific approach. Specific wastes should be dealt within such a system but in separate streams (as discussed in Section 2.10 and Fig.2.12). An effective waste management system includes one or more of the following options:

(a) Waste collection and transportation.

(b) Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.

(c) Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.

(d) Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.

(e) Disposal on land i.e. environmentally safe and sustainable disposal in landfills.

2.2.3 Functional Elements of Municipal Solid Waste Management

The activities associated with the management of municipal solid wastes from the point of generation to final disposal can be grouped into the six functional elements: (a) waste generation; (b) waste handling and sorting, storage, and processing at the source; (c) collection; (d) sorting, processing and transformation; (e) transfer and transport; and (f) disposal. The inter-relationship between the elements is identified in Fig. 2.7.

Waste Generation: Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation is, at present, an activity that is not very controllable. In the future, however, more control is likely to be exercised over the generation of wastes. Reduction of waste at source, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated.

Waste Handling, Sorting, Storage, and Processing at the Source: The second of the six functional elements in the solid waste management system is waste handling, sorting, storage, and processing at the source. Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials.

On-site storage is of primary importance because of public health concerns and aesthetic consideration. Unsightly makeshift containers and even open ground storage, both of which are undesirable, are often seen at many residential and commercial sites. The cost of providing storage for solid wastes at the source is normally borne by the household in the case of individuals, or by the management of commercial and industrial properties. Processing at the source involves activities such as backyard waste composting.

Collection: The functional element of collection, includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a materials processing facility, a transfer station, or a landfill disposal site.

Sorting, Processing and Transformation of Solid Waste: The sorting, processing and transformation of solid waste materials is the fourth of the functional elements. The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste (MSW) can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration.

Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (eg shredding), thermal (e.g. incineration without energy recovery) or chemical (e.g. encapsulation) techniques.

Transfer and Transport: The functional element of transfer and transport involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

Disposal: The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities (MRFs), residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth's mantle without creating nuisance or hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

2.3 HIERARCHY OF WASTE MANAGEMENT OPTIONS

Current thinking on the best methods to deal with waste is centred on a broadly accepted 'hierarchy of waste management' (arrangement in order of rank) which gives a priority listing of the waste management options available (see Fig. 2.8). The hierarchy gives important general guidelines on the relative desirability of the different management options. The hierarchy usually adopted is (a) waste minimisation/reduction at source, (b) recycling, (c) waste processing (with recovery of resources i.e. materials (products) and energy), (d) waste transformation (without recovery of resources) and (e) disposal on land (landfilling).

The highest rank of the ISWM hierarchy is waste minimisation or reduction at source, which involves reducing the amount (and/or toxicity) of the wastes produced. Reduction at source is first in the hierarchy because it is the most effective way to reduce the quantity of waste, the cost associated with its handling, and its environmental impacts.

The second highest rank in the hierarchy is recycling, which involves (a) the separation and sorting of waste materials; (b) the preparation of these materials for reuse or reprocessing; and (c) the reuse and reprocessing of these materials. Recycling is an important factor which helps to reduce the demand on resources and the amount of waste requiring disposal by landfilling.

The third rank in the ISWM hierarchy is waste processing which involves alteration of wastes to recover conversion products (e.g., compost) and energy. The processing of waste materials usually results in the reduced use of landfill capacity.

Transformation of waste, without recovery of products or energy, may have to be undertaken to reduce waste volume (e.g. shredding and baling) or to reduce toxicity. This is usually ranked fourth in the ISWM hierarchy.

Ultimately, something must be done with (a) the solid wastes that cannot be recycled and are of no further use; (b) the residual matter remaining after solid wastes have been pre-sorted at a materials recovery facility; and (c) the residual matter remaining after the recovery of conversion products or energy. Landfilling is the fifth rank of the ISWM hierarchy and involves the controlled disposal of wastes on or in the earth's mantle. It is by far the most common method of ultimate disposal for waste residuals. Landfilling is the lowest rank in the ISWM hierarchy because it represents the least desirable means of dealing with society's wastes.

It is important to note that the hierarchy of waste management is only a guideline.

Fig. 2.9 depicts how management of municipal solid waste as per the hierarchy of options leads to progressive reduction of waste reaching the landfill.

2.4 WASTE MINIMISATION

Waste minimisation or reduction at source is the most desirable activity, because the community does not incur expenditure for waste handling, recycling and disposal of waste that is never created and delivered to the waste management system. However, it is an unfamiliar activity as it has not been included in earlier waste management systems.

To reduce the amount of waste generated at the source, the most practical and promising methods appear to be (i) the adoption of industry standards for

product manufacturing and packaging that use less material, (ii) the passing of laws that minimise the use of virgin materials in consumer products, and (iii) the levying (by communities) of cess/fees for waste management services that penalise generators in case of increase in waste quantities.

Modifications in product packaging standards can result in reduction of waste packaging material or use of recyclable materials. Minimisation of use of virgin raw materials by the manufacturing industry promotes substitution by recycled materials.

Sorting at source, recycling at source and processing at source (e.g. yard composting) help in waste minimisation.

One waste management strategy used in some communities in developed countries is to charge a variable rate per can (or ton) of waste, which gives generators a financial incentive to reduce the amount of waste set out for collection. Issues related to the use of variable rates include the ability to generate the revenues required to pay the costs of facilities, the administration of a complex monitoring and reporting network for service, and the extent to which wastes are being put in another place by the generator and not reduced at source.

2.5 RESOURCE RECOVERY THROUGH MATERIAL RECYCLING

Material recycling can occur through sorting of waste into different streams at the source or at a centralised facility. Sorting at source is more economical than sorting at a centralised facility.

2.5.1 Sorting at Source

Sorting at source (home sorting) is driven by the existing markets for recyclable materials and the link between the house holder and the waste collector. The desirable home sorting streams are:

(a) Dry recyclable materials e.g. glass, paper, plastics, cans etc.,

(b) Bio-waste and garden waste,

(c) Bulky waste,

(d) Hazardous material in household waste,

(e) Construction and Demolition waste, and

(f) Commingled MSW (mixed waste).

At present recycling of dry recyclables does take place at the household level in India. However, source separation and collection of waste in streams of (b), (c), (d) and (e) has to be developed in most cities.

2.5.2 Centralised Sorting

Centralised sorting is needed wherever recyclable materials are collected in a commingled (mixed) state.

Hand sorting from a raised picking belt is extensively adopted in several countries.

Mechanised sorting facilities using magnetic and electric field separation, density separation, pneumatic separation, size separation and other techniques are used in some developed countries. Such facilities are usually prohibitively expensive in comparison to hand sorting.

In India, centralised sorting is not adopted. However, some intermediate sorting does occur after household wastes reach kerbside collection bins (dhalaos) through ragpickers. There is a need to formalise this intermediate sorting system or develop a centralised sorting facility to minimise recyclable materials reaching a waste processing facility or a landfill.

2.5.3 Sorting Prior to Waste Processing or Landfilling

Home sorting and centralised sorting processes normally recover most of the recyclable materials for reuse. However, a small fraction of such materials may escape the sorting process. Sorting is also undertaken just prior to waste processing, waste transformation or landfilling to recover recyclable materials. In a landfill, sorting may be carried out by ragpickers immediately after spreading of a layer of waste. In waste processing or transformation centres, manual sorting or size separation is usually undertaken.

Wherever manual sorting is adopted, care must be taken to ensure that sorters are protected from all disease pathways and work in hygienic conditions.

2.6 RESOURCE RECOVERY THROUGH WASTE PROCESSING

Biological or thermal treatment of waste can result in recovery of useful products such as compost or energy.

2.6.1 Biological Processes

Biological treatment involves using micro-organisms to decompose the biodegradable components of waste. Two types of processes are used, namely:

(a) Aerobic processes: Windrow composting, aerated static pile composting and in-vessel composting; vermi-culture etc.

(b) Anaerobic processes: Low-solids anaerobic digestion (wet process), high-solids anaerobic digestion (dry process) and combined processes.

In the aerobic process the utilisable product is compost. In the anaerobic process the utilisable product is methane gas (for energy recovery). Both processes have been used for waste processing in different countries – a majority of the biological treatment process adopted world-wide are aerobic composting; the use of anaerobic treatment has been more limited. Biological processes are discussed in chapter 14 & 15.

In India, aerobic composting plants have been used to process up to 500 tons per day of waste.

2.6.2 Thermal Processes

Thermal treatment involves conversion of waste into gaseous, liquid and solid conversion products with concurrent or subsequent release of heat energy. Three types of systems can be adopted, namely:

(a) Combustion systems (Incinerators): Thermal processing with excess amounts of air.

(b) Pyrolysis systems: Thermal processing in complete absence of oxygen (low temperature).

(c) Gasification systems: Thermal processing with less amount of air (high temperature).

Combustion system is the most widely adopted thermal treatment process world-wide for MSW. Though pyrolysis is a widely used industrial process, the pyrolysis of municipal solid waste has not been very successful. Similarly, successful results with mass fired gasifiers have not been achieved. However both pyrolysis and gasification can emerge as viable alternatives in the future.

Three types of combustion systems have been extensively used for energy recovery in different countries namely: mass-fired combustion systems (MASS), Refuse Derived Fuel (RDF), fired combustion systems and Fluidised Bed (FB) combustion systems are discussed in chapter 15.

To be viable for energy recovery through thermal processing, the municipal solid waste must possess a relatively high calorific value. In the MSW generated in developed countries, presence of significant quantity of paper and plastics yields a high calorific value of the MSW (typically above 2000 kcal/kg) which makes it suitable for thermal processing. In Indian MSW, the near absence of paper and plastics as well as the presence of high quantities of inert material, all combine to yield a low calorific value of the MSW (typically less than 1000 kcal/kg). In its mixed form, such waste may not be suitable for thermal processing. However, removal of inerts from Indian MSW as well as development of combustion system for low-calorific value wastes can result in a reversal of this position in the future.

2.6.3 Other Processes

New biological and chemical processes which are being developed for resource recovery from MSW are:

(a) Fluidised bed bio-reactors for cellulose production and ethanol production.

(b) Hydrolysis processes to recover organic acids.

(c) Chemical processes to recover oil, gas and cellulose.

(d) Others.

The economical viability of these processes is yet to be established.

2.7 WASTE TRANSFORMATION (WITHOUT RESOURCE RECOVERY) PRIOR TO DISPOSAL

At the end of all sorting processes, biological processes and thermal processes, the non-utilisable waste has to be disposed off on land. Prior to this disposal, waste may need to be subjected to transformation by mechanical treatment, thermal treatment or other methods to make it suitable for landfilling.

2.7.1 Mechanical Transformation

Sorting of waste may be undertaken to remove bulky items from the waste. Shredding of waste may be undertaken for size reduction to enable better compaction of waste.

2.7.2 Thermal Transformation

In regions where land space is very scarce (e.g. islands), waste with low calorific value may be subjected to combustion without heat recovery to reduce the volume of waste requiring disposal on land. Combustion transformation processes are similar to those discussed in Section 2.6.2.

2.7.3 Other Methods

To reduce toxicity of wastes e.g. hazardous wastes or biomedical wastes, special detoxification transformations may be undertaken. Some methods used are autoclaving, hydroclaving, microwaving, chemical fixation, encapsulation and solidification. These methods are usually not applied to MSW.

2.8. DISPOSAL ON LAND

Waste is disposed off on land in units called landfills which are designed to minimise the impact of the waste on the environment by containment of the waste. Usually three types of landfills are adopted. Landfills in which municipal waste is placed are designated as “MSW Landfills” or “Sanitary Landfills”. Landfills in which hazardous waste is placed are designated as “Hazardous Waste landfills”. Landfills in which a single type of waste is placed (e.g. only construction waste) are designated as “Monofills”.

2.9 COMPONENTS OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM

Fig. 2.10 shows the components of an integrated solid waste management system as applied to municipal solid waste and Fig. 2.11 depicts the detailed structure.

Currently, in India, source separation and collection of dry recyclables is fairly well developed at the household level, commercial centres and institutional areas. These recyclable are further removed by ragpickers at various intermediate stages. Central sorting, whether manual or mechanised, is not adopted.

Source separation of bio-waste, construction and demolition waste as well as hazardous waste is rarely done; consequently most of the waste collected is a mixture of these components. Such mixed waste is rarely suitable for biological

processing or thermal processing as it has high content of inert material, low calorific value and indeterminate mixing of hazardous elements (such as insecticides, paints, batteries etc.) at the micro level.

In some cities, good quality bio-waste is collected from fruit and vegetable markets and subjected to biological processing (aerobic) to produce compost. Such processing plants help reduce the quantity of waste reaching landfills.

Thermal processing of mixed municipal waste has not been successful in India. Biological processing of mixed municipal waste yields low quality compost which may have contaminants in excess of permissible limits.

Biological processing becomes viable once construction and demolition waste and hazardous waste streams are isolated from the bio-waste stream. Thermal processing of waste becomes viable only if sufficient high calorific value components (such as paper, plastic) are present in the waste.

Waste transformation is usually not a major component in an integrated municipal waste management system. However, some sorting and shredding at the landfill site may be undertaken as transformation processes prior to landfilling.

2.10 LINKAGES BETWEEN MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM AND OTHER TYPES OF WASTES GENERATED IN AN URBAN CENTRE

Other than municipal solid waste, the following types of waste may also be generated in urban centres:

(a) Industrial Waste – hazardous and non-hazardous waste from industrial areas within municipal limits.

(b) Biomedical Waste – waste from hospitals, slaughter houses etc.

(c) Thermal Power Plant Waste – Flyash from coal-based electricity generating plant within municipal limits.

(d) Effluent Treatment Plant Waste – Sludge from sewage treatment plants and industrial effluent treatment plants.

(e) Other Wastes – Special wastes from non-conforming areas or special units.

All waste streams must be managed by their own waste management system as shown in Fig. 2.12. However, the following aspects of inter-linkages between different waste streams are considered important.

(a) Different waste streams should not be managed in isolation. Inter-linkages between various streams should be encouraged if these lead to more efficient and economical recovery of the two important resources from solid waste – material and energy. For example, in some countries solid biodegradable waste and sewage are mixed to improve biological processing of solid waste.

(b) Different types of solid waste eventually reach any one of the following three types of landfills – MSW landfills, hazardous waste landfill or monofills for designated waste. Some important observations are:

  (i) All hazardous waste – whether from MSW stream, industrial waste stream or any other waste stream – should be disposed off in "Hazardous Waste Landfills".

  (ii) Large quantity non-hazardous waste (e.g. construction and demolition waste or flyash) should be disposed off in monofills (i.e. "Construction Waste Landfills" or "Ash Disposal Sites").

  (iii) Municipal solid waste after waste processing as well as non-hazardous, small quantity waste (typically less than 15% of the MSW quantity) from non-municipal sources can also be disposed off in MSW landfills, if the compatibility of such wastes with municipal waste is ascertained. Non-hazardous sludge (small quantity) can also be accommodated in a MSW landfill provided it has been dewatered and dried prior to disposal.

(c) At present, the solid waste management practices are to comply with the following sets of regulations:

  (i) Section dealing with conservancy and sanitation in the Municipal Acts of each state.

  (ii) Hazardous Waste Management and Handling Rules (1989), The Ministry of Environment & Forests (MoEF).

  (iii) Biomedical Waste Management and Handling Rules (1998), MoEF.

  (iv) Municipal Solid Waste Management and Handling Rules (Draft) (1998), MoEF.

  (v) Special notifications for other wastes from time to time, MoEF.

The inter-linkages between different waste streams are not clearly identified in these rules and regulations. The municipal solid waste managing authority should ensure that small-quantity waste from other streams is accepted for landfilling only after certification that the waste is non-hazardous by a regulatory authority (e.g. State Pollution Control Board).

2.11 MATERIALS FLOW CHART FOR MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM (1000 t.p.d. WASTE GENERATION)

To develop a solid waste management system for municipal solid waste, the following five steps are involved:

(a) Problem Definition and Statement of Objectives

(b) Inventory and Data Collection

(c) Development of Alternatives

(d) System Selection

(e) Implementation Methodology

The first step involves making a statement of the current problem and the corresponding objectives from decision makers.

The second step involves making an inventory and collecting data pertaining to the existing system as well as that required for the new system. This would involve data relating to waste generation, waste characteristics, transportation routes, collection systems, disposal sites, recycled materials markets etc.

In the third step, the data is evaluated and the feasibility of different technologies examined. Because a problem can have more than one solution, different alternatives are developed.

The alternatives are reviewed by the planners and decision-makers and a final set of technologies/programmes are selected. These set of technologies and programmes constitute the final management system.

The final step is the development of an implementation methodology for conversion of the existing system to the new system. This involves the setting up of schedules as well as monitoring mechanisms for implementation by the administrative organisations.

At the macro-level, the end result of an integrated waste management system is the development of materials flow chart, which shows how the waste is sorted, processed and transformed prior to disposal in a landfill. Two such flow charts are shown in Figs. 2.13 and 2.14. Fig. 2.13 shows a materials flow chart in a community generating 1000 TPD of waste without application of ISWM. Fig. 2.14 shows a materials flow chart developed based on the principles of ISWM for the twin objectives of (a) waste reduction and (b) effective management of waste still produced. The flow chart is conceptual in nature and does not suggest preference for any set of technologies. It is based on the assumption that the waste has about 17.5% recyclable material, 54% compostable material, 13.5% combustible material and the balance 15% as rejects. The materials flow chart for any system would have to be established on a case-to-case basis taking into account of (a) the waste quantities and characteristics at present, (b) the influence of sorting at source, intermediate/central sorting on the waste quantities and characteristics and (c) the applicability of various technologies to post-sorted waste. Since developments in waste processing are taking place at a rapid pace, the onus of demonstrating the feasibility of a technology usually lies with the technology supplier. The role of the planner and the decision-maker is usually to ensure that post-processing products in the gaseous, liquid and solid states meet the desired environmental standards.

CHAPTER 3

COMPOSITION AND QUANTITY OF SOLID WASTE

3.1 INTRODUCTION

The information on the nature of wastes, its composition, physical and chemical characteristics – and the quantities generated are basic needs for the planning of a Solid Waste Management system.

3.1.1 Terminology and Classification

In the literature, it is observed that various authors have used different terminology to describe the nature of wastes. In this text, ‘composition’ refers to the limited list of components or constituents, such as paper, glass, metal, plastic and garbage, into which an aggregate of municipal waste may conveniently be separated. ‘Characteristics’ on the other hand, refers to those physical and chemical properties, which are relevant to the storage, collection, treatment and disposal of waste such as density, moisture content, calorific value and chemical composition. In addition to these general terms, there are a number of more specific terms which, for greater clarity, must also be defined. A comprehensive list of definitions is therefore presented later in this chapter. Some terms, like ‘domestic waste’ and municipal waste refer to the sources of the wastes, while others, such as ‘garbage’, ‘street waste’ and ‘hazardous waste’, indicate the types of wastes.

3.1.2 Variations in Composition and Characteristics

An examination of the composition and characteristics of wastes in different parts of the country underscores the profound influences of national income, socio-economic conditions, social developments and cultural practices, and thereby focuses attention on the importance of obtaining the data locally.

Since different kinds of solid waste management system are designed for the future as well as the present, careful consideration should be given to changes that may occur during the design life of a system. Changes are inevitable, occur at an increasingly rapid rate in response to the increasing pace of social and technological development and the nature and extent of such changes can not be predicted with accuracy. A built-in flexibility in the waste management system hence becomes essential. Nevertheless, it is possible to identify some of the factors that are likely to cause changes in waste composition and characteristics, which will enable planners to make reasonable judgements about the future.

3.2 DEFINITIONS AND CLASSIFICATION OF SOLID WASTES

In order to plan, design and operate a solid waste management system, a thorough knowledge of the quantities generated, the composition of wastes and its characteristics are essential. As a first step, a proper definition of the terms is necessary to avoid the general confusion that is common in the usage of these terms.

3.2.1 Definitions

There are many terms, which relate to the types and sources of wastes and these too must be defined. Based on the source, origin and type of waste a comprehensive classification is described below:

(i) Domestic/Residential Waste:

This category of waste comprises the solid wastes that originate from single and multi-family household units. These wastes are generated as a consequence of household activities such as cooking, cleaning, repairs, hobbies, redecoration, empty containers, packaging, clothing, old books, writing/new paper, and old furnishings. Households also discard bulky wastes such as furniture and large appliances which cannot be repaired and used.

(ii) Municipal Waste:

Municipal waste include wastes resulting from municipal activities and services such as street waste, dead animals, market waste and abandoned vehicles. However, the term is commonly applied in a wider sense to incorporate domestic wastes, institutional wastes and commercial wastes.

(iii) Commercial Waste:

Included in this category are solid wastes that originate in offices, wholesale and retail stores, restaurants, hotels, markets, warehouses and other commercial establishments. Some of these wastes are further classified as garbage and others as rubbish.

(iv) Institutional Waste:

Institutional wastes are those arising from institutions such as schools, universities, hospitals and research institutes. It includes wastes which are classified as garbage and rubbish as well as wastes which are considered to be hazardous to public health and to the environment.

(v) Garbage:

Garbage is the term applied to animal and vegetable wastes resulting from the handling, storage, sale, preparation, cooking and serving of food. Such wastes contain putrescible organic matter, which produces strong odours and therefore attracts rats, flies and other vermin. It requires immediate attention in its storage, handling and disposal.

(vi) Rubbish:

Rubbish is a general term applied to solid wastes originating in households, commercial establishments and institutions, excluding garbage and ashes.

(vii) Ashes:

Ashes are the residues from the burning of wood, coal, charcoal, coke and other combustible materials, for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities at power generating plants and factories these wastes are classified as industrial wastes. Ashes consist of a fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass.

(viii) Bulky Wastes:

In this category are bulky household wastes which cannot be accommodated in the normal storage containers of households. For this reason they require special collection. In developed countries bulky wastes are large household appliances such as cookers, refrigerators and washing machines as well as furniture, crates, vehicle parts, tyres, wood, trees and branches. Metallic bulky wastes are sold as scrap metal but some portion is disposed of at sanitary landfills.

(ix) Street Sweeping:

This term applies to wastes that are collected from streets, walkways, alleys, parks and vacant lots. In the more affluent countries manual street sweeping has virtually disappeared but it still commonly takes place in developing countries, where littering of public places is a far more widespread and acute problem. Mechanised street sweeping is the dominant practice in the developed countries. Street wastes include paper, cardboard, plastic, dirt, dust, leaves and other vegetable matter.

(x) Dead Animals:

This is a term applied to dead animals that die naturally or accidentally killed. This category does not include carcass and animal parts from slaughterhouses which are regarded as industrial wastes. Dead animals are divided into two groups, large and small. Among the large animals are horses, cows, goats, sheep, hogs and the like. Small animals include dogs, cats, rabbits and rats. The reason for this differentiation is that large animals require special equipment for lifting and handling during their removal. If not collected promptly, dead animals are a threat to public health because they attract flies and other vermin as they putrefy. Their presence in public places is particularly offensive and emits foul smell from the aesthetic point of view.

(xi) Construction and Demolition Wastes:

Construction and demolition wastes are the waste materials generated by the construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. It mainly consists of earth, stones, concrete, bricks, lumber, roofing materials, plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream, but when generated in large amounts at building and demolition sites, it is generally removed by contractors for filling low lying areas and by urban local bodies for disposal at landfills.

(xii) Industrial Wastes:

In the category are the discarded solid material of manufacturing processes and industrial operations. They cover a vast range of substances which are unique to each industry. For this reason they are considered separately from municipal wastes. It should be noted, however, that solid wastes from small industrial plants and ash from power plants are frequently disposed of at municipal landfills. For details please refer to **Chapter 6** on **"Industrial Wastes"**.

(xiii) Hazardous Wastes:

Hazardous wastes may be defined as wastes of industrial, institutional or consumer origin which, because of their physical, chemical or biological characteristics are potentially dangerous to human and the environment. In some cases although the active agents may be liquid or gaseous, they are classified as solid wastes because they are confined in solid containers. Typical examples are: solvents, paints and pesticides whose spent containers are frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes cause explosions in incinerators and fires at landfill sites. Others, such as pathological wastes from hospitals and radioactive wastes, require special handling at all time. Good management practice should ensure that hazardous wastes are stored, collected, transported and disposed off separately, preferably after suitable treatment to render them innocuous. For details please refer to **Chapter 7** on **"Bio-Medical Wastes"**.

(xiv) Sewage Wastes:

The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derive from the treatment of organic sludge from both the raw and treated sewage. The inorganic fraction of raw sewage such as grit is separated at the preliminary stage of treatment, but because it entrains putrescible organic matter which may contain pathogens, must be buried/disposed off without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but invariably its use for this purpose is uneconomical. The solid sludge therefore enters the stream of municipal wastes unless special arrangements are made for its disposal.

3.2.2 Classification

Because of the heterogeneous nature of solid wastes, no single method of classification is entirely satisfactory. In some cases it is more important for the solid waste specialist to know the source of waste, so that classifying wastes as domestic, institutional or commercial, for example, is particularly useful. For other situations, the types of waste, garbage, rubbish, ashes, street waste is of greater significance because it gives a better indication of the physical and chemical characteristics of the waste. The principal classification is given in **Table 3.1.** The first three types, garbage, rubbish and ashes are those which make up the bulk of municipal wastes, derived principally from households, institutions and commercial areas. These wastes pose the most alarming/serious problems in urban areas.

Table 3.1 : Classification of Solid Wastes

TYPES OF SOLID WASTE	DESCRIPTION	SOURCES
Food waste (garbage)	Wastes from the preparation, cooking, and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meats and vegetable	
Rubbish	**Combustible** (primary organic) paper, cardboard, cartons wood, boxes, plastics, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings **Noncombustible** (primary inorganic) metals, tin cans, metal foils dirt, stones, bricks, ceramics, crockery, glass bottles, other mineral refuse	Households, institutions and commercial such as hotels, stores, restaurants, markets, etc.
Ashes and Residues	Residue from fires used for cooking and for heating buildings, cinders, clinkers, thermal power plants.	
Bulky waste	Large auto parts, tyres, stoves refrigerators, others large appliances, furniture, large crates, trees, branches, palm fronts, stumps, flotage	
Street waste	Street sweepings, Dirt, leaves, catch basin dirt, animal droppings, contents of litter receptacles dead animals	Streets, sidewalks, alleys, vacant lots, etc.
Dead animals	Small animals: cats, dogs, poultry etc. Large animals: horses, cows etc.	
Construction & demolition waste	Lumber, roofing, and sheathing scraps, crop residues, rubble, broken concrete, plaster, conduit pipe, wire, insulation etc.	Construction and demolition sites, remodeling, repairing sites
Industrial waste & sludges	Solid wastes resulting from industry processes and manufacturing operations, such as food processing wastes, boiler house cinders, wood, plastic and metal scraps and shaving, etc. Effluent treatment plant sludge of industries and sewage treatment plant sludges, coarse screening, grit & septic tank	Factories, power plants, treatment plants, etc.
Hazardous wastes	Hazardous wastes: pathological waste, explosives, radioactive material, toxic waste etc.	Households, hospitals, institution, stores, industry, etc.
Horticulture Wastes	Tree-trimmings, leaves, waste from parks and gardens, etc.	Parks, gardens, roadside trees, etc.

Source: Solid Waste Management in Developing Countries by Bhide & Sunderasan, INSDOC April, 1983

3.3 COMPOSITION, CHARACTERISTICS AND QUANTITIES

3.3.1 Need for Analysis

An analysis of the composition, characteristics and quantities of solid wastes is essential for the following reasons:

- It provides the basic data on which the management system is planned, designed and operated
- The changes/trend in composition and quantity of waste over a period of time are known which help in future planning
- It provides the information for the selection of equipment and appropriate technology
- It indicates the amount and type of material suitable for processing, recovery and recycling
- The forecast trends assist designers and manufacturers in the production of vehicles and equipment suitable for future needs.

For such information to be of the widest possible benefit it must be collected by a responsible national, regional or local authority and made available to all who require it.

3.3.2 Field Investigations

Field investigations are necessary for providing the basic data on solid wastes and are carried out in three ways:

- Weighing of vehicles at disposal sites
- Sorting of wastes into predetermined components for weighing and sampling in order to determine the percentage of each component and the physical and chemical characteristics of the wastes.
- Visiting institutional and industrial sites to identify wastes being generated and disposal methods being used.

The weighing of loaded and unloaded vehicles is accomplished with a weighing scale or weighbridge with a capacity of 20,000 kg. The loaded vehicles are weighed when they enter the disposal site and empty vehicles are weighed when they leave the site after unloading. Weighing is carried out each day of weighing period in order to determine the average weight. Ideally the weighing scale should be operated during the entire daily period of operation of the landfill site, round the clock, if necessary. A shift system should be employed, the weighing team comprising four workers for each scale – a supervisor, an assistant and two helpers moving the scale platform to the desired spacing for each vehicle.

The quantities of waste measured at disposal sites more correctly reflect the quantities being disposed rather than those generated since the measurements do not include:

- Waste salvaged at the site of generation
- Waste disposed of in unauthorised places-empty lots, alleys, ditches etc.
- Waste salvaged by collectors
- Waste salvaged at the disposal site

Differences between the two are insignificant with well-managed collection systems, enlightened public attitude and strict enforcement of legislation. This is frequently not the case, particularly in some cities and it is then necessary to measure waste quantities at source. Flintoff (1984) describes a method for collecting samples with the active cooperation of householders wherein containers or plastic bags are filled by a representative number of householders and labeled before being taken to the depot where the contents are weighed and the volume measured.

Sorting is carried out manually, each sample size being about 100-150 kg for desired accuracy of analysis. This process separates the waste into pre-determined components, each component being separately weighed. Equipment used for this purpose includes:

- A sorting table, 3m long x 1.5m wide
- A measuring box, 1m long x 0.5m wide x 1m high
- Bins or boxes for storage of about 60 litre i.e. 0.06 m^3 capacity sorted material
- A platform weighing machine – 500 Kg

This procedure may not be feasible in developing countries where time for study and resources are limited. For such situations a suitable procedure of sample collection is described.

3.3.3 Number of Samples to be Collected

Solid waste is very heterogeneous in nature and its composition varies with place and time. Even samples obtained from the same place (sampling point) on the same day, but at different time may show totally different characteristics. Due to this reason the method by which the sample is collected and the number of samples collected is critical.

In the planning of sample survey, a stage is always reached at which some decision must be made about the size of the sample. This decision is extremely important as unduly large number of samples result in waste of resources, while less number of samples diminish the accuracy and utility of the results.

A method of determining the number of samples by statistical technique has been suggested by Dennis E. Carruth and Albert J. Klee*.

The data on physical analysis of solid waste is presented in percentage. Since the percentage of one constituent differs greatly from the other, the data follows a multinomial distribution. So the data is subjected to a normalising transformation by using arcsin function.

$$Y = 2 \arcsin \sqrt{X}$$

Where X is the original percentage value of a component expressed as a decimal; and

Y is transformed value of X.

To determine the number of samples required for composition analysis following formula is used.

$$n = (ZS/\delta)^2$$

Where,

n	=	number of samples
Z	=	the standard normal deviate for confidence level desired
S	=	estimated standard deviation (transformed basis)

* Analysis of Solid Waste Composition, Statistical Technique to Determine Sample Size, SW-19ts, US Department of Health, Education and Welfare, Bureau of Solid Waste Management, 1969

δ = sensitivity (transformed basis)

$= |2 \arcsin \sqrt{X} - 2 \arcsin \sqrt{X \pm \Delta}|$

The value for Δ is set according to the desired level of precision. In this case the values for acceptable precision are obtained from the range e.g. paper content in Indian Cities ranges between 2.91 – 6.43%. The average percentage of paper content is 4.036. Therefore X = p.04036. (Y = 0.4045). There will be two values i.e. 0.02126 and 0.02394. The choice of sign for $X \pm \Delta$ is positive if X is less than 0.5. Therefore, corresponding values for $X \pm \Delta$ are 0.0516 & 0.0643 and transformed values Y -> 0.4582 & 0.5126.

Therefore $\delta_1 = |2 \arcsin \sqrt{0.04036} - 2 \arcsin \sqrt{0.0516}|$

$= |0.4045 - 0.4582|$

$= 0.0537$

and $\delta_2 = |2 \arcsin \sqrt{0.04036} - 2 \arcsin \sqrt{0.0643}|$

$= |0.4045 – 0.5126|$

$= 0.1081$

Substituting the values of δ_1 in equation $n = (ZS/\delta_1)^2$

We get n = 6

Z = 1.96, Z+0.684

Similarly substituting value of δ_2 in equation $n = (ZS/\delta_2)^2$

We get n = 2

Therefore samples required for paper is in the range of 2-6.

Similarly number of samples required for other constituents were calculated and results are given in **Table 3.2.**

An advantage of this method is that number of samples can also be determined for any important chemical parameter. For example, carbon to nitrogen (C/N) ratio is important for determining the suitability of the solid waste for composting. The number of samples required can be calculated from values of C/N ratio. Normally the range of C/N ratio in Indian Municipal Solid Waste is 21.13-30.94 and the typical average value of C/N ratio is 25.66. The desired precision can be obtained from upper and lower values of the range and the average.

Table 3.2 : Critical Statistics Obtained from Typical Indian Data

	X	**Y**	**V**	**Range (no. of samples)**
Paper	0.04036	0.4045	0.0742	2 – 6
Rubber, Leather & Synthetics	0.00596	0.1545	0.0298	13 – 35
Glass	0.00558	0.1495	0.0285	9 – 10
Metals	0.00506	0.1424	0.0277	13 – 20
Total Compostable Matter	0.4221	1.4144	0.1766	1 – 36
Inert	0.4793	1.4979	0.0731	2 – 3

X -> mean of n observations expressed as decimals
Y -> transformed value of X
V -> standard deviation

Data for C/N ratio is transformed as follows:

C/N ratio Average value	X	Y	δ	no. of samples
25.66	0.2566	1.0570	0.1137 0.0980	1

Number of samples can be calculated separately for nitrogen and carbon. The number of samples required in case of nitrogen is about 380 and that for carbon is one. Similarly number of samples can be calculated for Phosphorus, Potassium and other chemical parameters.

It is evident from the statistical results obtained from the method mentioned above that the number of samples to be taken does not exceed thirty-five in any case. Though larger number of samples will increase precision, the required number of samples for increased precision increase at a very large disproportionate rate making it very uneconomic and analysis a hard task. The basic aim should be to obtain a sample size which is a compromise between economy and precision.

3.3.4 Collection of Samples of Solid Waste

When collecting samples of municipal solid waste major collection sites are identified which are covering a larger size of population. Based on the type of area such as residential, commercial, industrial, market, slum etc. sampling points are distributed uniformly all over the study area. The sampling points are further classified based on economic status of population such as high, middle and low-income group.

About 10 kg of Municipal Solid Waste (MSW) is collected from ten points from outside and inside of the solid waste heap. The total quantity of waste so collected is thoroughly mixed and then reduced by method of quartering till a samples of such a size is obtained which can be handled in the laboratory. The sample so obtained is subjected to physical analysis, determination of moisture and then the sample is processed for further chemical analysis.

Samples collected for physical and chemical analysis are double bagged in plastic bags, sealed and sent to the laboratory for analysis, each sample being in the range 10 to 12 kg. Wastes from industries and institutions are usually investigated by visiting the facility, viewing the waste handling system and completing a questionnaire with the assistance of the plant manager or senior technical personnel.

3.3.5 Composition and Characteristics

The composition and characteristics of municipal solid wastes vary throughout the world. Even in the same country it changes from place to place as it depends on number of factors such as social customs, standard of living, geographical location, climate etc. MSW is heterogeneous in nature and consists of a number of different materials derived from various types of activities. Even then it is worthwhile to make some general observation to obtain some useful conclusions.

- The major constituents are paper and putrescible organic matter;
- Metal, glass, ceramics, plastics, textiles, dirt and wood are generally present although not always so, the relative proportions depending on local factors;
- The average proportion of constituents reaching a disposal site(s) for a particular urban area changes in long term although there may be significant seasonal variations within a year.

For these reasons an analysis of the composition of solid waste, for rich and poor countries alike, is expressed in terms of a limited number of constituents. It is useful in illustrating the variations from one urban center to another and from country to country. Data for different degrees of national wealth (annual per-capita income) are presented in **Table 3.3.** Waste composition also varies with socio-economic status within a particular community, since income determines life-style – consumption patterns and cultural behaviour.

Table 3.3 : Patterns of Composition, Characteristics and Quantities

	Low Income Countries (1)	**Middle Income Countries (2)**	**High Income Countries (3)**
Composition : (% by weight)			
Metal	0.2 – 2.5	1 – 5	3 – 13
Glass, Ceramics	0.5 – 3.5	1 – 10	4 – 10
Food and Garden waste	40 – 65	20 – 60	20 – 50
Paper	1 – 10	15 – 40	15 – 40
Textiles	1 – 5	2 – 10	2 – 10
Plastics/Rubber	1 – 5	2 – 6	2 – 10
Misc. Combustible	1 – 8	–	–
Misc. Incombustible	–	–	–
Inert	20 – 50	1 – 30	1 – 20
Density (kg/m^3)	250 – 500	170 – 330	100 – 170
Moisture Content (% by wt)	40 – 80	40 – 60	20 – 30
Waste Generation (kg/cap/day)	0.4 – 0.6	0.5 – 0.9	0.7 – 1.8

(1) Countries having a per capita income less than US$360 (1978 prices)
(2) Countries having a per capita income US$360-3500 (1978 prices)
(3) Countries having a per capita income greater than US$3500 (1978 prices)

Source : Holmes, J : Managing Solid Waste in Developing Countries.

Several conclusions may be drawn from this comparative data:

- The proportion of paper waste increases with increasing national income;
- The proportion of putrescible organic matter (food waste) is greater in countries of low income than those of high income;

- Variation in waste composition is more dependent on national income than geographical location, although the latter is also significant;
- Waste density is a function of national income, being two to three times higher in the low-income countries than in countries of high income;
- Moisture content is also higher in low-income countries; and
- The composition of waste in a given urban center varies significantly with socio-economic status (household income).

3.3.5.1 Characteristics of Municipal Solid Waste in Indian Urban Centres

National Environmental Engineering Research Institute (NEERI) has carried out extensive studieson characterisation of solid waste from 43 cities during 1970-1994. The average characteristics have been presented in **Tables 3.4 and 3.5.** The paper content generally varies between 2.9 to 6.5% and increases with the increase in population. The plastics, rubber and leather contents are lower than the paper content, and do not exceed 1% except in metropolitan cities. The metal content is also low, viz. less than 1%. The low values are essentially due to the large scale recycling of these constituents. During a study in Bombay (1993-94), samples were collected both at the source as well as disposal sites to ascertain the extent of recycling. The paper is recycled on a priority basis while the plastics and glass are recycled to a lesser extent. The biodegradable fraction is quite high, essentially due to the habit of using fresh vegetables in India. The high biodegradable fraction also warrants frequent collection and removal of solid waste from the collection points. The ash and fine earth content of Indian municipal solid waste is high due to the practice of inclusion of the street sweepings, drain silt, and construction and demolition debris in municipal solid waste. The proportion of ash and fine earth reduces with increase in population due to improvements in the road surfaces. Percentage of inert material increases with the increase in population may be due to fast than construction and demolition waste find its way into the municipal solid waste disposal stream. High ash and earth content increases the densities of municipal solid waste which are between 350 and 550 kg/m^3 in Indian cities.

The chemical characteristics indicate that the organic content of the samples on a dry weight basis ranges between 20 to 40%. The nitrogen, phosphorus and potassium content of the municipal solid waste ranges between 0.5 to 0.7%, 0.5 to 0.8% and 0.5 to 0.8% respectively. The calorific value ranges between 800-1000 kcal/kg. Knowledge of the chemical characteristics is essential in selecting and designing the waste processing and disposal facilities.

Ragpickers are observed to be more active in bigger cities. They prefer to remove paper, plastics, rags and packaging and such other material, which is light and also have a high calorific value. The remaining waste hence tends to have a higher inert content and a lower calorific value.

The demolition activity is observed to increase with population leading to increased inert content and reduced organic content in MSW.

Table 3.4 : Physical Characteristics of Municipal Solid Wastes in Indian Cities

Population Range (in million)	Number Of Cities Surveyed	Paper	Rubber, Leather And Synthetics	Glass	Metals	Total compostable matter	Inert
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to 1.0	15	2.95	0.73	0.35	0.32	40.04	48.38
1.0 to 2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	3	3.18	0.48	0.48	0.59	56.67	49.07
> 5	4	6.43	0.28	0.94	0.80	30.84	53.90

All values in table 3.4 are in percent, and are calculated on net weight basis

Source : Background material for Manual on SWM, NEERI, 1996

Table 3.5 : Chemical Characteristics of Municipal Solid Wastes in Indian Cities

Population range (in million)	No. of Cities surveyed	Moisture %	Organic matter %	Nitrogen as Total Nitrogen %	Phosphorous as P_2O_5 %	Potassium as K_2O %	C/N Ratio	Calorific value* in kcal/kg
0.1-0.5	12	25.81	37.09	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	15	19.52	25.14	0.66	0.56	0.69	21.13	900.61
1.0-2.0	9	26.98	26.89	0.64	0.82	0.72	23.68	980.05
2.0-5.0	3	21.03	25.60	0.56	0.69	0.78	22.45	907.18
> 5.0	4	38.72	39.07	0.56	0.52	0.52	30.11	800.70

All values, except moisture, are on dry weight basis.
*Calorific value on dry weight basis

Source : Background material for Manual on SWM, NEERI, 1996.

3.3.6 Quantities

The information regarding waste quantity and density coupled with waste generation rate (by weight), is important while assessing the payload capacity of the collection equipment. It is possible to estimate the number of vehicles required for the collection and transportation of waste each day.

While per capita waste generation is a statistic, which is necessary for indicating trends in consumption and production, the total weight and volume of wastes generated by the community served by the management system are of greater importance in planning and design. As in all other aspects of data collection for the planning and design phases, data on waste generation, weight and volume should be collected by each authority for application in its own area of operation.

3.3.6.1 Per Capita Quantity of Municipal Solid Waste in Indian Urban Centres

The quantity of waste from various cities was accurately measured by NEERI. On the basis of quantity transported per trip and the number of trips made per day the daily quantity was determined. The quantity of waste produced is lesser than that in developed countries and is normally observed to vary between 0.2-0.6 kg/capita/day. Value upto 0.6 kg/capita/day are observed in metropolitan cities **(Table 3.6).** The total waste generation in urban areas in the country is estimated to be around 38 million tonnes per annum.

Forecasting waste quantities in the future is as difficult as it is in predicting changes of waste composition. The factors promoting change in waste composition are equally relevant to changes in waste generation. An additional point, worthy of note, is the change of density of the waste as the waste moves through the management system, from the source of generation to the point of ultimate disposal. Storage methods, salvaging activities, exposure to the weather, handling methods and decomposition, all have their effects on changes in waste density. As a general rule, the lower the level of economic development, the greater the change between generation and disposal. Increases in density of 100% are common in developing countries, which mean that the volume of wastes decreases by half.

Table 3.6 : Quantity of Municipal Solid Waste in Indian Urban Centres

Population Range (in million)	Number of Urban Centres (sampled)	Total population (in million)	Average per capita value (kg/capita/day)	Quantity (tonnes/day)
< 0.1	328	68.300	0.21	14343.00
0.1 – 0.5	255	56.914	0.21	11952.00
0.5 – 1.0	31	21.729	0.25	5432.00
1.0 – 2.0	14	17.184	0.27	4640.00
2.0 – 5.0	6	20.597	0.35	7209.00
> 5.0	3	26.306	0.50*	13153.00

* 0.6 kg/capita/day generation of MSW observed in metro cities

Source : Background material for Manual on SWM, NEERI, 1996

3.3.6.2 Estimation of Future Per Capita Waste Quantity

For purposes of project identification, where an indication of service level must be estimated and data from the project preparation stage have not yet been developed, the following municipal refuse generation rates are suggested:

Residential refuse	:	0.3 to 0.6 kg/cap/day
Commercial refuse	:	0.1 to 0.2 kg/cap/day
Street sweepings	:	0.05 to 0.2 kg/cap/day
Institutional refuse	:	0.05 to 0.2 kg/cap/day

If industrial solid waste is included in municipal refuse for collection and/or disposal purposes, from 0.1 to 1.0 kg/cap/day may be added at the appropriate step where the municipality must estimate service delivery requirements. These generation rates are subject to considerable site-specific factors and are required to be supported by field data.

3.3.6.3 Relation between Gross National Product (GNP) and Municipal Solid Waste Generation

The consumption of raw materials and finished product by the community is directly proportional to the Gross National Product (GNP) of the country. Since the solid waste quantities are directly proportional to the quantity of material consumed the increase in per capita solid waste quantities would be directly proportional to the per capita increase in GNP. **Table 3.7** shows the relation between GNP and expected generation of municipal solid waste, based on the study conducted by the United Nations in 1995.

Table 3.7 : Relation between GNP and Expected Generation of Municipal Solid Waste

Sl. No.	Country	During the year 1995			During the year 2025		
		GNP Per Capita (US$)	Urban Population (% of Total)	Urban MSW Generation (kg/capita/day)	GNP Per Capita (US$)	Urban Population (% of Total)	Urban MSW Generation (kg/capita/day)
Low Income		**490**	**27.8**	**0.64**	**1,050**	**48.8**	**0.6-1.0**
1.	Nepal	200	13.7	0.50	360	34.3	0.6
2.	Bangladesh	240	18.3	0.49	440	40.0	0.6
3.	Myanmar	240	26.2	0.45	580	47.3	0.6
4.	Vietnam	240	20.8	0.55	580	39.0	0.7
5.	Mangolia	310	60.9	0.60	560	76.5	0.9
6.	India	340	26.8	0.46	620	45.2	0.7
7.	Lao PDR	350	21.7	0.69	850	44.5	0.8
8.	China	620	30.3	0.79	1,500	54.5	0.9
9.	Sri Lanka	700	22.4	0.89	1,300	42.6	1.0
Middle Income		**1,410**	**37.6**	**0.73**	**3,390**	**61.1**	**0.8-1.5**
10.	Indonesia	980	35.4	0.76	2,400	60.7	1.0
11.	Philippines	1.050	54.2	0.52	2,500	74.3	0.8
12.	Thailand	2,740	20.0	1.10	6,650	39.1	1.5
13.	Malaysia	3,890	53.7	0.81	9,400	72.7	1.4
High Income		**30,990**	**79.5**	**1.64**	**41,140**	**88.2**	**1.1-4.5**
14.	Korea, Republic of	9,700	81.3	1.59	17,600	93.7	1.4
15.	Hong Kong	22,990	95.0	5.07	31,000	97.3	4.5
16.	Singapore	26,730	100	1.10	36,000	100	1.1
17.	Japan	39,640	77.6	1.47	53,500	84.9	1.3

(1 US$ = 40 INR)

Source: "What a Waste", Solid Waste Management in Asia, Urban Development Sector Unit, East Asia and Pacific Region, October, 1998

3.3.6.4 Rate of Increase Based on Experience in Other Cities

If data from other cities having registered similar pattern of development in the past is available, it can be used. However, data from other similar cities on rate of increase in per capita per day of solid waste may not be readily available. Due to difference in socio-economic factor, migration of population, industrialisation and waste quantities, a comparison of increase in per capita waste of one Indian city with that of comparable cities in other developing countries will also not be applicable.

3.3.6.5 Seasonal Variations

Seasonal variations in waste quantities must be accommodated by the management system. They arise from seasonal factors with respect to both climate, cultural and religious events. During monsoon, the waste becomes wet and heavy and total tonnage increases. Quantities of solid waste may also increase during cultural and religious festivals. Climate affects the generation of vegetative waste (yard and garden) or plant growth responds to favorable temperatures and soil to autumn while in tropical areas, where temperatures are always favorable, maximum growth is in the season of rainfall. At the end of the growth season (autumn dry season) leaves may comprise a significant proportion of the solid wastes.

3.3.7 Physical Characteristics

3.3.7.1 Density

A knowledge of the density of a waste i.e. its mass per unit volume (kg/m^3) is essential for the design of all elements of the solid waste management system viz. Community storage, transportation and disposal. For example, in high-income countries, considerable benefit is derived through the use of compaction vehicles on collection routes, because the waste is typically of low density. A reduction of volume of 75% is frequently achieved with normal compaction equipment, so that an initial density of 100 kg/m^3 will readily be increased to 400 kg/m^3. In other words, the vehicle would haul four times the weight of waste in the compacted state than when the waste is uncompacted. The situation in low-income countries is quite different: a high initial density of waste precludes the achievement of high compaction ratio. Consequently, compaction vehicles offer little or no advantage and are not cost-effective.

Significant changes in density occur spontaneously as the waste moves from source to disposal, as a result of scavenging, handling, wetting and drying by the weather, vibration in the collection vehicles. The values shown in **Table 3.8** reflect densities at the pick-up point.

Table 3.8 : Density of Municipal Solid Wastes in Some Cities

Sl.No.	City	Density (Kg/m^3)
1.	Bangalore	390
2.	Baroda	457
3.	Delhi	422
4.	Hyderabad	369
5.	Jaipur	537
6.	Jabalpur	395
7.	Raipur	405

Source : Solid Waste Management in Developing Countries INSIDOC, 1983

N.B.: The above figures may be taken as indicative and actual field measurements must be made while designing solid waste management schemes for towns and cities.

Density is as critical in the design of a sanitary landfill as it is for the storage, collection and transportation of waste. Efficient operation of a landfill requires compaction of the waste to optimum density after it is placed.

Bulk Density Measurement

Materials and apparatus:

- Wooden box of l m^3 capacity
- Wooden box of 0.028 m^3 capacity
- Spring balance weighing upto 50 kg.

Procedure: The solid waste should be taken in the smaller 0.028 m^3 box to give a composite sample, from different parts of the heap of waste, then weighed with the help of a spring balance. After weighing, this smaller box (0.028 m^3) is emptied in bigger l m^3 box and the weight of the waste poured into the bigger box is noted. This is repeated till the larger box is filled to the top. The waste should not be compacted by pressure.

Fill the 1 m^3 box three times and take the average. Thus the weight per cubic meter is obtained.

3.3.7.2 Moisture Content

Moisture content of solid wastes is usually expressed as the weight of moisture per unit weight of wet material.

$$\text{Moisture Content (\%)} = \frac{\text{Wet weight} - \text{dry weight}}{\text{Wet weight}} \times 100$$

A typical range of moisture contents is 20 – 45% representing the extremes of wastes in an arid climate and in the wet season of a region having large precipitation. Values greater than 45% are however not uncommon. Moisture increases the weight of solid waste and therefore the cost of collection and transport. Consequently, waste should be insulated from rainfall or other extraneous water.

Moisture content is a critical determinant in the economic feasibility of waste treatment and processing methods by incineration since energy (e.g. heat) must be supplied for evaporation of water and in raising the temperature of the water vapour.

Climatic conditions apart, moisture content is generally higher in low-income countries because of the higher proportion of food and yard waste.

3.3.7.3 Size of Waste Constituents

The size distribution of waste constituents in the waste stream is important because of its significance in the design of mechanical separators and shredder and waste treatment process. This varies widely and while designing a system, proper analysis of the waste characteristics should be carried out.

3.3.7.4 Calorific Value

Calorific value is the amount of heat generated from combustion of a unit weight of a substance, expressed as kcal/kg. The calorific value is determined experimentally using Bomb calorimeter in which the heat generated at a constant temperature of 25^{O}c from the combustion of a dry sample is measured. Since the test temperature is below the boiling point of water, the combustion water remains in the liquid state. However, during combustion the temperature of the combustion gases remains above $100^{O}c$ so that the water resulting from combustion is in the vapour state. **Table 3.5** shows typical values of the residue and calorific value for the components of municipal solid waste.

While evaluating incineration as a means of disposal or energy recovery, the following points should be kept in view:

- Organic material yields energy only when dry;
- The moisture contained as free water in the waste reduces the dry organic material per kilogram of waste and requires a significant amount of energy for evaporation; and
- The ash content of the waste reduces the proportion of dry organic material per kilogram of waste. It also retains some heat when removed from the furnace.

3.3.8 Chemical Characteristics

A knowledge of chemical characteristics of waste is essential in determining the efficacy of any treatment process. Chemical characteristics include (i) chemical; (ii) bio-chemical; and (iii) toxic.

Chemical: Chemical characteristics include pH, Nitrogen, Phosphorus and Potassium (N-P-K), total Carbon, C/N ratio, calorific value.

Bio-Chemical: Bio-Chemical characteristics include carbohydrates, proteins, natural fibre, and biodegradable factor.

Toxic: Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

The waste may include lipids as well.

3.3.8.1 Classification

A knowledge of the classes of chemical compounds and their characteristics is essential in proper understanding of the behaviour of waste as it moves through the waste management system. The products of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the percent dry weights of each class. The rate and products of decomposition are assessed through chemical analysis. Calorific value indicates the heating value of solid waste. Chemical characteristics are very useful in assessment of potential of methane gas generation. The various chemical components normally found out in municipal solid waste are described below. The product of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the per cent dry weight of each class.

(i) Lipids:

Included in this class of compounds are fats, oils and grease. The principal sources of lipids are garbage, cooking oils and fats. Lipids have high calorific values, about 38000 kcal/kg, which makes waste with a high lipid content suitable for energy recovery processes. Since lipids in the solid state become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition. They are biodegradable but because they have a low solubility in waste, the rate of biodegradation is relatively slow.

(ii) Carbohydrates:

Carbohydrates are found primarily in food and yard waste. They include sugars and polymers of sugars such as starch and cellulose and have the general formula $(CH_2O)_X$. Carbohydrates are readily biodegraded to products such as carbon dioxide, water and methane. Decomposing carbohydrates are particularly attractive for flies and rats and for this reason should not be left exposed for periods longer than is necessary.

(iii) Proteins:

Proteins are compounds containing carbon, hydrogen, oxygen and nitrogen and consist of an organic acid with a substituted amine group (NH_2). They are found mainly in food and garden wastes and comprise 5-10% of the dry solids in solid waste. Proteins decompose to form amino acids but partial decomposition can result in the production of amines, which have intensely unpleasant odours.

(iv) Natural Fibres:

This class includes the natural compounds, cellulose and lignin, both of which are resistant to biodegradation. They are found in paper and paper products and in food and yard waste. Cellulose is a larger polymer of glucose while lignin is composed of a group of monomers of which benzene is the primary member. Paper, cotton and wood products are 100%, 95% and 40% cellulose respectively. Since they are highly combustible, solid waste having a high proportion of paper and wood products, are suitable for incineration. The calorific values of ovendried paper products are in the range 12000 – 18000 kcal/kg and of wood about 20000 kcal/kg, which compare with 44200 kcal/kg for fuel oil.

(v) Synthetic Organic Materials (Plastic):

In recent years, plastics have become a significant component of solid waste accounting for 5-7%. Plastic being non-bio-degradable, its decomposition does not take place at disposal site. Besides, plastic causes choking of drains and environmental pollution when burnt under uncontrolled condition. Recycling of plastics is receiving more attention, which will reduce the proportion of this waste component at disposal sites.

(vi) Non-combustibles:

Materials in this class are glass, ceramic, metals, dust, dirt, ashes and construction. Non-combustibles account for 30-50% of the dry solids.

3.4 CONCLUSION

No rational decisions on municipal solid wastes system are possible until data of composition and quantity of solid waste are available. The method and capacity of storage, the correct type of collection vehicle, the optimum size of crew and the frequency of collection depend mainly on volume and density of wastes. Climate also has some influence. The disposal method may be dependent on the type of material recycled, organic content of waste, which could be composted, and the combustible material, which could be a source of energy.

CHAPTER 4
CONSTRUCTION AND DEMOLITION WASTE

4.1 INTRODUCTION

Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway, remodelling etc. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc. A part of this waste comes to the municipal stream.

These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container. It is not uncommon to see huge piles of such waste, which is heavy as well, stacked on roads especially in large projects, resulting in traffic congestion and disruption. Waste from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. Often it finds its way into surface drains, choking them. It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects).

It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. Projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55,000 million cu.m. An additional 750 million cu.m. aggregates would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors.

While retrievable items such as bricks, wood, metal, titles are recycled, the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India. Recycling of concrete and masonry waste is, however, being done abroad in countries like U.K., USA, France, Denmark, Germany and Japan.

Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to make concrete for road construction and building material. Work on recycling of aggregates has been done at Central Building Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi.

The study report stresses the importance of recycling construction waste, creating awareness about the problem of waste management and the availability of technologies for recycling.

According to a study commissioned by Technology Information, Forecasting and Assessment Council(TIFAC), 70% of the construction industry is not aware of recycling techniques. The study recommends establishment of quality standards for recycled aggregate materials and recycled aggregate concrete. This would help in setting up a target product quality for producers and assure the user of a minimum quality requirement, thus encouraging him to use it.

4.2 CHARACTERISTICS

This category of waste is complex due to the different types of building materials being used but in general may comprise the following materials :

Major components

- Cement concrete
- Bricks
- Cement plaster
- Steel (from RCC, door/window frames, roofing support, railings of staircase etc.)
- Rubble
- Stone (marble, granite, sand stone)
- Timber/wood (especially demolition of old buildings)

Minor components

- Conduits (iron, plastic)
- Pipes (GI, iron, plastic)

- Electrical fixtures (copper/aluminium wiring, wooden baton, bakelite/plastic switches, wire insulation)
- Panels (wooden, laminated)
- Others (glazed tiles, glass panes)

4.3 STORAGE OF CONSTRUCTION AND DEMOLITION WASTE

These wastes are best stored at source, i.e., at the point of generation. If they are scattered around or thrown on the road, they not only cause obstruction to traffic but also add to the workload of the local body. All attempts should be made to stick to the following measures:

- All construction/demolition waste should be stored within the site itself. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore.
- Attempts should be made to keep the waste segregated into different heaps as far as possible so that their further gradation and reuse is facilitated.
- Material, which can be reused at the same site for the purpose of construction, levelling, making road/pavement etc. should also be kept in separate heaps from those, which are to be sold or landfilled.
- The local body or a private company may arrange to provide appropriate number of skip containers/trolleys on hire which may be parked at the site and removed with skip lifters or tractors as the case may be.
- Whenever a new streamlined system is introduced in a municipality, the local body may consider using its old vehicles, especially, tractors and trailers or old lorries or tippers for this purpose.
- For large projects involving construction of bridges, flyovers, subways etc., special provision should be made for storage of waste material. Depending on the storage capacity, movement of the waste has to be planned accordingly. Otherwise, it would result in job constraint as well as traffic bottlenecks.
- This subject is often neglected in case of repair/maintenance of roads, water pipes, underground telephone and electric cables etc. It is not uncommon to see that after such work, the waste remains piled for months on the roads or pavements. The concerned departments and contractors must co-ordinate with the municipality for removal of the debris generated. The municipality while giving permission for such work should clearly sort out the issue of removal of the debris and should insist that immediately after the job is over, the road should be repaired and brought back to its normal shape.

4.4 COLLECTION AND TRANSPORTATION

If the construction debris is stored in skips, then skip lifters fitted with hydraulic hoist system should be used for efficient and prompt removal. In case, trailers are used, then tractors may remove these. For handling very large volumes, front-end loaders in combination with sturdy tipper trucks may be used so that the time taken for loading and unloading is kept to the minimum.

For small generators of construction debris, e.g., petty repair/maintenance job, there may be two options – (i) specific places for such dumping by the local body and (ii) removal on payment basis.

In case of small towns where skips and tipping trailers are not available, manual loading and unloading should be permitted.

Close co-ordination between the Sanitary Department, Municipal Engineering Department and Town Planning Department is essential if there is no consolidated Solid Waste Management Department to take care of the construction and demolition waste in addition to other municipal garbage.

4.5 RECYCLING AND REUSE

The use of these materials basically depends on their separation and condition of the separated material. A majority of these materials are durable and therefore, have a high potential of reuse. It would, however, be desirable to have quality standards for the recycled materials. Construction and demolition waste can be used in the following manner:

- Reuse (at site) of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition.
- Sale / auction of material which can not be used at the site due to design constraint or change in design.
- Plastics, broken glass, scrap metal etc. can be used by recycling industries.
- Rubble, brick bats, broken plaster/concrete pieces etc. can be used for building activity, such as, leveling, under coat of lanes where the traffic does not constitute of heavy moving loads.
- Larger unusable pieces can be sent for filling up low-lying areas.
- Fine material, such as, sand, dust etc. can be used as cover material over sanitary landfill.

Metropolitan and mega cities usually generate huge quantities of wastes because of large-scale building and other developmental activities. They may identify suitable sites where such waste can be temporarily stored and some physical treatment can be carried out. These sites may have the following features:

- Compared to the general waste treatment/disposal/landfill site such sites may be suitably located near the municipal boundaries, because the inert waste do not cause odour or pollution, provided adequate steps are taken to reduce dust and noise during handling. Since these wastes are heavy, their transportation cost can also be reduced to some extent if the distance to be carried is less.
- At this site, different kinds of waste should be kept in separate heaps.
- Arrangement for size grading can also be planned so that reuse is facilitated. This can be simply done by erecting sturdy metallic screens of different sizes at an angle and putting the waste over them with the help of a front-end loader.
- The graded material should be kept in separate heaps with appropriate label and direction.
- Sale or auction of these materials can also be planned from time to time.

4.6 DISPOSAL

Being predominantly inert in nature, construction and demolition waste does not create chemical or biochemical pollution. Hence maximum effort should be made to reuse and recycle them as indicated above (4.5). The material can be used for filling/leveling of low-lying areas. In the industrialised countries, special landfills are sometimes created for inert waste, which are normally located in abandoned mines and quarries. The same can be attempted in our country also for cities, which are located near open mining quarries or mines where normally sand is used as the filling material. However, proper sampling of the material for its physical and chemical characteristics has to be done for evaluating its use under the given circumstances.

4.7 PLANNING AND MANAGEMENT ASPECTS

The concerned civic authorities should make a plan for gainful use of construction debris. The low lying areas, which need to be filled up for the purpose of building activity, may be mapped and a contingency plan prepared so that whenever a demolition or construction activity takes place, its debris can be directed to such places in order of priority. However, such activity should be planned and implemented strictly under supervision and approval of the concerned authority.

4.8 INSTITUTIONAL AND REGULATORY ASPECTS

There should be a proper institutional mechanism to take care of the collection, transportation, intermediate storage (if necessary), utilisation and disposal of the construction and demolition waste. In a number of municipalities, the Sanitary Department or the Health Department is responsible for the municipal garbage whereas the Engineering or the Planning Department is responsible for construction and demolition waste. Under such circumstances, it is extremely important that either the Solid Waste Management Department is made responsible for collection of construction and demolition waste or these departments work in close co-ordination.

It is essential that proper accountability is fixed and official information is readily available regarding day to day situation.

Private enterprise can be gainfully employed for the collection and transportation of the waste. Strict control of the concerned civic authorities is essential. If the municipality has suitable vehicles and containers, these can be leased to the private enterprises. There must be proper contract agreement protecting the genuine interests of the private enterprise and the civic authorities.

Thus the following four options are possible :

1. The total activity may be contracted out.
2. Only vehicles may be leased out by the civic body to the private contractor for transport of debris with his own labour, i.e., labour contract.
3. The vehicles may be hired by the local body from private sources for transport of debris with municipal labour.
4. The total activity may be carried out by the Department, i.e., the municipality.

The civic authority should consider the following points and after deliberations get them approved by the competent authority, except the those which already exist in their municipal act.

- The civic authority should notify that no person should dispose of construction/demolition waste on the streets/pavements/storm drainage/open land belonging to the municipality or the government. In case such waste is dumped on a private land, the owner of such land would be accountable for the act and would be held responsible for any degradation of the surrounding environment or causing of any pollution.

- Such waste should be stored within the premises till they are removed from the site to a place notified/permitted by the local body.
- The primary responsibility for removal of such waste would be that of the generator of such waste. The civic authority would charge suitably (at least full cost recovery) if they provide containers on hire and provide service for removal of the waste. In such case the local body would become the owner of the waste and would have the right to sale or auction the same.
- The generator of waste should inform the concerned civic authority in writing in advance before undertaking such activity and also deposit such fees as necessary according to the notifications of the municipality by way of container rent, stacking (on a public road/place) or hauling charges. There should be provision of suitable penalty clause by way of moderate to heavy fines etc. (depending on the severity of the offence) for violation of these rules and also for littering of construction debris.
- In case of new construction, the advance is to be deposited with the application for sanction of the building plan. The charges would be notified by the civic authority and would be refundable after due deductions in case of compliance of the stipulated laws. In case of any default, the whole amount would be confiscated.
- These rules/notifications would also be valid for Government, Semi-Government and Public Sector Departments.

CHAPTER 5

SLAUGHTER HOUSE WASTE AND DEAD ANIMALS

5.1 INTRODUCTION

As per 1989 survey, India has the world's largest population of livestock, with nearly 191 million cattle. 70 million Buffaloes, 139 million Sheep and Goat, 10 million Pigs and over 200 million poultry. About 36.5% of Goat, 32.5% of Sheep, 28% of Pigs, 1.9% of Buffaloes and 0.9% cattle are slaughtered every year. The reported per capita availability of meat in India is about 1.4 kg per annum, which is rather low compared to 60-90 kg in European countries.

As reported by the Ministry of Food Processing, as of 1989, a total of 3616 recognized slaughter houses slaughter over 2 million cattle and buffaloes, 50 million sheep and goat, 1.5 million pigs and 150 million poultry annually, for domestic consumption as well as for export purposes.

While the slaughter houses come under the purview of the animal husbandry division of Ministry of Agriculture mainly for the purpose of funding towards expansion and modernization activities, the respective local bodies are mainly responsible for day-to-day operation/maintenance of the slaughter houses. Most of the slaughter houses in the country are service-oriented and, as such, perform only the killing and dressing of animals without an onsite rendering operations. Most of the slaughter houses are more than 50 years old without adequate basic amenities viz. proper flooring, ventilation, water supply, lairage, transport etc. In addition to these deficiencies, slaughter houses suffer from very low hygiene standard posing a major public health and environmental hazards due to discrete disposal of waste and highly polluted effluent discharge. Unauthorised and illicit slaughtering has also increased manifold and thus the related problems.

5.2 MAGNITUDE OF THE PROBLEM

With growing annual per capita meat consumption, high meat export potential, large non-utilisation of potential meat animals, the development of meat industry in India is controlled not by the Government but the existing market forces. The unorganised nature of this trade is the main feature in this industry that has not been able to use state of the art of technology available in global meat market. This sector is facing many problems and constraints while going for modernisation as under-mentioned:

- Subjects of slaughtering of animals and related activities are governed as State subjects under the provisions of Article 48 of the Constitution of India.
- There are religious and political controversies over the large animal slaughter particularly bullocks.
- A vociferous pressure group emerging out of religious feelings does hinder the modernisation of slaughter houses.
- The Government's policies do not permit slaughtering of younger animals. Therefore, illegal slaughtering of calves is done in every city.
- Moreover the introduction of humane slaughter methods have proved unsuccessful due to certain religion constraints, whereas existence of powerful religious concern over cruelty to animals can not be ignored.
- Due to Government control, religious beliefs and some of the constraints as explained above the ante-mortem and post-mortem inspections cannot be done at inadequately equipped slaughter houses and also it leads to illegal slaughtering of animals at a very high level.
- Animals are often available for slaughter only when they are useless for any other purpose.
- Lack of care during the transportation results into cruelty to animals, weight loss and high mortality.
- Many of the animals are of poor breeds for meat production and suffer from malnutrition, endemic diseases and widespread parasitic infestation.
- The meat industry is considered as unclean, unsocial and low caste occupation.
- Comparatively small number of rich butchers who exploit the local labour force presently dominates the entire meat industry.
- The long chain of middlemen results in high mark of prices between the farmers' gate and the terminal market.

Because of the reasons stated above and the fact that most of the slaughter houses in the country are more than 75 years old and also there is a noticeable increase in illegal activities of slaughtering animals, the meat industry does not meet the standards for discharge of effluents as laid down and notified under the Environment (Protection) Act, 1986.

Eating habit of non-vegetarian population is generally controlled by the prevailing market price of meat. It has been observed that meat from large animals is sold at one third of the price of mutton from sheep/goat or chicken and fish. The availability of large animals, i.e. bullocks and buffaloes has also increased over the years due to better breeding practices adopted in animal husbandry programmes, better veterinary care of animals and ever growing mechanisation of agriculture. Since the requirement of bullocks for farming purposes has decreased over the years, the dairy farmers sell the male calves at a younger age. The calf leather also fetches a good price for the butcher. The facilities available at meat markets are not good enough to keep the meat fresh for longer time. The butchers are not ready to bear the transportation costs for transporting meat from the slaughter houses to the shops. Hence, most of the butchers prefer to slaughter animals next to their shops. This particular scenario of illegal slaughtering at the door-step of the shops poses a great hazard to the local governments not only from public health point of view but also for the disposal of wastes in a scientific manner.

The wastes from slaughter houses and packaging houses are similar chemically to domestic sewage, but are considerably more concentrated. They are almost wholly organic, chiefly having dissolved and suspended material. The principal deleterious effect of these wastes on streams and water courses is their deoxygenation. The type of waste produced by the separate operations are shown as under:

Source	**Waste**
Stockyard	manure
Killing floor	blood
Dehairing	hair and dirt
Insides removal	paunch manure and liquor
Rendering	stick liquor or press liquor
Carcass dressing	flesh, grease, blood, manure
By-products	grease, offal

The typical characteristics of the effluent coming out from the slaughter house are as follows:

	Parameters		**Characteristic**
1.	Quantity	-	2000 cum/day
2.	Total solids	-	4000 to 5000 mg/1
3.	BOD	-	4000 mg/1
4.	COD	-	8000 mg/1
5.	pH	-	6 to 7

5.3 CLASSIFICATION

At present there are no official norms for classification of slaughter houses. However, depending upon the type of animals slaughtered, the slaughter houses are classified into:

- Large animal (i.e. cattle, buffalo etc.) slaughter house
- Goat and sheep slaughter house
- Pig slaughter house
- Poultry slaughter house

In order to assess the variations in pollution load with respect to number of animals slaughtered, Bovines and Goat & Sheep slaughter houses are further classified into following categories:

- Large Scale - More than 200 large animals i.e. Bovines per day or more than 1000 goat and sheep per day.
- Medium Scale - More than 50 and upto 200 large animals or more than 300 upto 1000 goat and sheep/day.
- Small Scale - Less than 50 Bovines and 300 goat and sheep per day.

Large scale slaughter houses are located mainly in big cities, medium slaughter houses in district/towns while the small scale slaughter houses are scattered all over the country.

5.4 OPERATIONS DURING SLAUGHTERING OF ANIMALS

5.4.1 Present Scenario

5.4.1.1 Slaughtering

In India mostly slaughtering of animals is done either by way of ***halal or jhatka*** method. Halal is the method preferred by Muslims and jhatka by the Hindus/Christians/Sikhs, etc. To slaughter the animals in a humane way stunning of the animals is prescribed, but in most of the cases stunning before slaughtering has yet not been adopted due to certain religious feelings.

5.4.1.2 Bleeding

In both the above methods of slaughtering, blood collection is not done immediately on slaughtering and most of the blood goes down into municipal drains causing pollution. Blood of the animals, which can be collected for making use in pharmaceutical industry, is thus by and large lost. Due to inadequate facilities at the slaughter houses and scattered illegal slaughtering of animals, a very few slaughter housed collect blood.

5.4.1.3 Dressing

Due to lack of means and tools, dehiding of the carcasses is done on the floor itself, which causes contamination of the meat. The hides and skins are spread on the floor of the slaughtering area. Similarly legs, bones, hooves etc. are not removed immediately from the slaughtering area.

5.4.1.4 Evisceration

This particular process during slaughtering generates maximum amount of waste. The butchers who carry out illegal slaughtering of animals generally throw visceral material at the community bins and wash the small intestines at their shops itself and thus create pollution problem.

5.5 MEASURES PROPOSED TO IMPROVE THE SLAUGHTER HOUSE WASTE MANAGEMENT

5.5.1 Liquid Waste/Effluent

During the above mentioned operations the waste generated is of liquid and solid nature. The liquid waste should be washed away by safe potable and constant supply of fresh water at adequate pressure throughout the premises of slaughtering. The waste water from slaughter house is heavy in pollution and, therefore, it should not be allowed to mix with the municipal drain system without pre-treatment meeting sewage standards as per the Bureau of Indian Standards(BIS). The waste water treatment system should essentially comprise of:

(i) self cleaning type screening or two stage screening (Bar type);

(ii) anaerobic treatment;

(iii) aerobic treatment; and

(iv) filter press for dewatering of the sludge.

For the treatment of liquid waste/effluent from slaughter houses, the guidelines contained in the Manual on Sewerage & Sewage Treatment published by the Ministry of Urban Development, 1993 may be followed. The standards prescribed in the Environment Protection Act, 1986, as per ***Annexure-5.1,*** must be adhered by each slaughter house.

5.5.2 Collection of Blood

The blood available from the slaughter houses should be collected and made use of in pharmaceutical industry. Bleeding areas should be clearly identified in the slaughter houses and blood drains should be and collection should be done immediately so that its full potential could be utilized.

5.5.3 Improved Method of Dressing

At each slaughter house adequate tools should be provided for dehiding of the animals, hides and skins should be immediately transported out of the slaughtering area in a closed wheel-barrow or similar other devices. In no case the hides and skins should be spread on the floor of the slaughtering area for inspection. Legs, bones, hooves etc. should also be removed immediately from the slaughtering area through a spring load floor chute or closed wheel-barrow.

5.5.4 Evisceration

At slaughter houses adequate compartments for immediate separation and disposal of condemned material must be provided. The authority must take care that intestines are not punctured during evisceration to avoid contamination of carcasses.

5.5.5 Safe Disposal of Waste Products

Slaughtering of animals generates wastes consisting of non edible offal (like lungs, large intestines, various glands, animal tissues, organs, various body parts, etc.) stomach/intestinal contents, dung, sludge from waste water treatment, bones, etc. All these types of wastes are required to be disposed by adopting methods like rendering/controlled incineration/burial/composting/anaerobic digestion etc. The estimated waste generated in a slaughter house is stated as under-mentioned:

Sl.No.	Type of slaughter house	Capacity Annual	Daily Waste Generated
1.	Large	Large animals>40,000 Small animals>6,00,000	6-7 Tonnes/day
2.	Medium	Large animals = 10,001-40,000 Small animals = 1,00,001-6,00,000	2-6 Tonnes/day
3.	Small	Large animals upto 10,000 Small animals upto 1,00,000	0.5-1 Tonne/day

5.5.6 Odours Control

The tropical climate of our country enhances the process of degeneration of any tissue material remaining as a waste in the premises of the slaughter houses. Therefore, the slaughter house premises always give a particular stink. In order to avoid this stinking odour proper ventilation of slaughtering halls, washing of the floors with non-poisonous disinfectants and if need be use of aerobic deodorants must be provided at each slaughter house.

5.5.7 Modernisation of Slaughter House

The slaughter houses are normally controlled by local bodies, which should follow the standards prescribed, but due to non-existence of modernised slaughter houses, environmental pollution arising out of the slaughtering activities cannot be controlled. The local bodies must, therefore, take up modernisation of slaughter houses and achieve the pollution control norms.

5.5.8 Curbing Activities of Illegal Slaughtering of Animals

The places where illegal slaughtering is taking place should be carefully identified and the illegal activity should be curbed by the local body with the help of local police to ensure that slaughtering takes place at the slaughter house only under hygienic conditions and meat eating population gets fresh and disease free meat. This will also prevent clogging of drains due to illegal dumping of animal waste into the drains.

Till the activity of illegal slaughtering is not brought under control, the waste generated out of this illicit practice needs to be managed by the urban local bodies by putting community bins for collection of this waste so that the waste does not get mixed up with the domestic waste and can be disposed of separately.

5.5.9 Provision of Dry Rendering Plants

In most of the cities the animals dying of natural death are carried away to outskirts of the city limits by the people who perform the job of dehiding of the carcasses. After dehiding these carcasses are left in open. Vultures and other animals feed on meat of these carcasses. This entire activity is a nuisance to the aviation industry and a hazard for public health. The carcass utilization plant which are run by adopting dry rendering process plants should be provided at all the major towns to process the dead animal carcasses in a scientific manner. These plants should process the solid waste generated from the slaughterhouses as well as the places of illegal slaughter. The products of the rendering plants are widely used as meat meal/bone meal, etc. The slaughter house waste can also be subjected to bio-methanation as resources recovery.

Department of Animal Husbandry, Ministry of Agriculture, Government of India is providing substantial financial assistance for setting up of slaughter houses and carcass utilisation centres. The details including guidelines are given as per ***Annexure-5.2***.

5.6 The Supreme Court of India, High Courts in States and Lower Courts have taken serious view on environmental pollution and have in several cases ordered closing down of existing slaughter houses and flaying units and other such highly polluting industries. Therefore, it is the right time for the State Governments and Urban Local Bodies to chalk out plans for modernisation of slaughter houses. Central Pollution Control Board (CPCB) has brought out ***"Draft Guidelines for Sanitation in Slaughter Houses"*** during August, 1998 and the same is appended as per ***Annexure-5.3***.

The Bureau of Indian Standards has also brought out the Indian Standard, IS : 4393 : 1979, as basic requirement for Abattoir (First Revision).

ANNEXURE 5.1

DRAFT GUIDELINES FOR SANITATION IN SLAUGHTER HOUSE

1. PREAMBLE

i) The standards for discharge of effluents from the slaughter houses have been laid down and notified under the Environment (Protection) Act, 1986.

ii) Most of the slaughter houses in the country are more than 50 years old with inadequate basic amenities like proper flooring, water supply, ventilation etc.. At present, their condition is far from satisfactory. The guidelines are suggested to help in improving existing slaughter houses and setting up of new slaughter houses on modern lines with emphasis on greater utilization of wastes.

2. SCOPE

The guidelines cover basic amenities in slaughter house, operations including humane slaughtering, implant control measures, by-product recovery and waste management systems. The overall objective is to maintain good hygiene and sanitation in slaughter house and to minimize environmental problems.

3. APPLICATION

The guidelines shall apply to every local authority (Municipal Corporation, Municipal Council, Municipality, Nagar Palika, Cantonment Board) or person(s) operating a slaughter house. These guidelines shall be applicable to all cities/towns/villages where slaughter houses exist.

4. TERMINOLOGY

Carcass – The part of animal body that is used for meat.

Composting – A controlled process involving microbial degradation.

Dissolved Air Floatation – Separation of low density contaminant from water using minute air bubbles attached to individual particles to increase the buoyancy of the particle.

Evisceration – The process of removing inner organs of the body, particularly organs of thorax and abdomen such as the intestines, heart, lung, liver, kidneys etc.

Hygiene – The science of health and its preservation.

Incineration – It is a controlled combustion process in which the waste is burnt and converted into gases and a residue containing little or no combustible material.

Lairage – Facility of slaughter house where animals are delivered and rested prior to slaughtering.

Lard – Processed pig fat, processing is done by boiling raw fat material.

Offal – Part of the animal that remains after the carcasses have been removed.

Rendering – Facility for processing by-product from slaughter house and meat processing units into animal feed, bone meal etc.

Rumen – The first stomach of ruminants like cow, buffalo and goat sheep which ruminates

Slaughter House – The building, premises or place which is used for slaughtering of animals/birds for human consumption.

Viscera – The organ of the great cavity of the body which are removed after slaughtering.

5. LOCATION

The slaughter houses should be located outside or on the periphery of a city or town and shall be away from an airport. Care should, however, be taken to see that these are easily accessible to the patrons and do not adversely affect the transport of meat to the market place. Main service such as potable water, electricity and proper hygienic waste disposal facilities are a prerequisite and should be taken care of.

6. BASIC AMENITIES

i) The slaughter house shall have the following essential facilities:

a) Reception area for animals;
b) Lairage;
c) Facilities for ante-mortem inspection;
d) Segregation ward for sick/diseased animals;

e) Carrying out humane slaughtering;

f) Flaying, dressing and washing of carcasses;

g) Handling carcasses and edible offal;

h) Handling by-products;

i) Inspection of meat and disposal of unfit meat for human consumption;

j) Refrigerated room; and

k) Laboratory.

ii) The floor of slaughter hall and dressing area of slaughter house must be impervious, of good quality marbled slab/cement-tiles or good quality cement concreting with proper gradient for draining waste waters. Walls up to 1.5 to 2 meters from floor should be surfaced with approved quality white glazed tiles or other equivalent material. Suitable type of ventilation system like air conditioning, air circulation, exhaust fans etc. should be provided.

iii) The slaughter house should have an adequate separation between clean and dirty sections, which shall be arranged in such a way that from introduction of a live animal into the slaughter house upto the emergence of meat and offal classed as fit for human consumption there shall be a continuous process; without any possibilities of reversal, inter-section or overlapping between the live animals and meat, and between meat and by-products or waste.

iv) There should be rails with hooks of suitable rust proof metal for bleeding, dressing and hanging of carcasses in slaughter house.

7. OPERATIONS

i) *Slaughtering:* Arrangement should be provided in slaughter house for humane slaughtering. Large animals may be stunned mechanically by captive pistol or gun. In case of goat, sheep and pit, electric stunner may be used. An animal should not be stunned and slaughtered in sight of other animals.

ii) *Bleeding:* The bleeding area should be so located that the blood should not be spashed on other animals being slaughtered or on carcasses being skinned. Blood drains and collection should be immediate and proper.

iii) *Dressing:* Dressing of carcasses should not be done on floor. Adequate means and tools for dehiding or belting of the animals should be provided. Hides and skins should be immediately transported either in a closed wheel barrow or by chute provided with self closing door. In no case, the hides or skins should be spread on floor for inspection. Means for immediate disposal of legs, horns, hooves etc. should be provided through spring load floor chutes or side wall door or closed wheel barrows.

iv) *Evisceration:* There should be adequate contrivances for immediate separation and disposal of condemned material. Care should be taken too not to puncture intestine during evisceration to avoid contamination of carcass.

8. WATER SUPPLY

i) Sufficient, safe, potable and constant supply of fresh water shall be available at adequate pressure through out the premises. There should be arrangement of hot water supply in slaughter hall and work rooms during working hours.

ii) At all convenient points, sterilizing facilities should be provided. Hot water is required at not less than 82°C for frequent sterilizing of equipments and tools.

iii) Suitable facilities for washing of hands (including adequate supply of hot and cold water, nail brushes, soap or detergent) should be provided for persons working in slaughter house.

iv) Every sanitary convenience in a slaughter house should be supplied with water by means of suitable flushing appliance.

9. MAN POWER

The workers engaged in slaughtering, dressing etc. should be well educated and trained in their respective operations. Workers should have regular medical check up and should be medically fit to handle meat (food). They should be provided with necessary uniform and protective clothing and they should always use and maintain them in a clean and sanitary condition through out their working period.

10. INPLANT MEASURES

i) High efficiency spray nozzles with quick shot off in carcass washing, evisceration line and all cleaning purposes should be installed for effective cleaning and to reduce water consumption.

ii) Dry cleaning step for all clean-up operations followed by controlled and efficient wet cleaning should be introduced to reduce pollution load in wastewater.

iii) Proper segregation and collection of blood should be practiced in every slaughter house.

iv) The dry procedures for collection of stomach and intestinal contents should be adopted. In no case, discharge of stomach and intestinal contents be allowed to discharge into drains.

v) Hairs/feathers and other screenable solids should be removed from the wastewater as close to the place of generation/discharge as possible.

11. RECOVERY FROM WASTE

i) Blood should be collected by pharmaceutical companies for manufacturing of haemotonic preparations. Alternatively, blood plasma could be used in sausage preparations. Blood can also be converted to blood meal which, after mixing and drying with rumen digesta can be used as animal feed.

ii) Rumen digesta contains 10-20% proteins, vitamins and essential minerals which, after processing/drying is an ideal animal feed. Alternatively, rumen digesta can be used as manure after composting.

iii) Fat should be collected separately and rendered into tallow or lard by using wet or dry rendering processes. Indirect heat is used to melt fat and evaporate moisture from animal tissue. Tallow and lard is a valuable raw material for several chemical industries.

iv) Dissolved Air Floatation (DAF) is a proven method not only for pre-treatment of wastewater but also for fat and protein recovery. Prior to floatation, coagulation and flocculation are required. The collected float with solid content of

16-18% consists mainly of proteins and fats. Coagulation of proteins and melting of fats is carried out in the subsequent protein recovery system consisting of a heat exchanger and dryer. The dried product, with a protein content of approximately 98% can be used as animal feed.

12. WASTE MANAGEMENT

For implementation of effective waste management system, the slaughter houses have been classified into three categories i.e. large, medium and small. The criterion of classification is specified in Schedule-I.

i) *Effluent:* Wastewater of a slaughter house should be subjected to appropriate treatment system as given in Schedule-II to meet the prescribed standards before it is discharged. The standard notified under the Environment (Protection) Act, 1986 are presented in Schedule-III.

ii) *Solid Waste:* All solid wastes arising in the slaughter house shall be properly graded and disposed of by methods specified in Schedule-IV.

iii) *Odours:* Proper ventilation system should be provided which, besides meeting the provisions of factory act, can also facilitate to avoid off objectionable odours.

Schedule-I
(Guideline 12)

Classification of Slaughter Houses

Sl.No.	Category of Slaughter House	Criterion
1.	Large	Annual Slaughtering Capacity: Large Animals > 40,000 and Goats/Sheeps > 6,00,000 Or Daily Live Weight Killed > 70 Tonne
2.	Medium	Annual Slaughtering Capacity: Large Animals 10,001 – 40,000 and Goats/Sheeps 1,00,001 – 6,00,000 Or Daily Live Weight Killed 15 – 70 Tonne
3.	Small	Annual Slaughtering Capacity: Large Animals Upto 10,000 and Goats/Sheeps Upto 1,00,000 Or Daily Live Weight Killed Upto 15 Tonne

Schedule-II
[Guideline 12(i)]

Wastewater Treatment Systems

Sl.No.	Category of Slaughter House	Essential Treatment
1.	Large	Self cleaning type screening, anaerobic treatment, aerobic treatment and filter press for dewatering of sludge
2.	Medium	Two stage screening (bar type), anaerobic pond and polishing pond
3.	Small	-do-

Schedule-III
[Guideline 12(i)]

Standards

Sl.No.	Category of Slaughter House/Unit	Parameters	Limit not to exceed, mg/l
1.	Large Slaughter House (Capacity above 70 TLWK/day)	Bio-chemical Oxygen Demand (BOD_5) at 20^0C	100
		Suspended Solids	100
		Oil and Grease	10
2.	Medium and Small Slaughter House (Capacity Upto 70 TLWK/day)	Bio-chemical Oxygen Demand (BOD_5) at 20^0C	500
3.	Meat Processing		
	a) Frozen Meat	Bio-chemical Oxygen Demand (BOD_5) at 20^0C	30
		Suspended Solids	50
		Oil and Grease	10
	b) Raw Meat from Own Slaughter House	Bio-chemical Oxygen Demand (BOD_5) at 20^0C	30
		Suspended Solids	50
		Oil and Grease	10
	c) Raw Meat from other Sources	----	Disposal via Screen and Septic Tank
4.	Sea Food Industry	Bio-chemical Oxygen Demand (BOD_5) at 20^0C	30
		Suspended Solids	50
		Oil and Grease	10

Note: (I) TLWK – Tonne of live weight killed. (ii) In case of disposal into municipal sewer where sewage is treated, the industries shall install screen and oil and grease separation units. (iii) The industries having slaughter house along with meat processing units will be considered in meat processing category as far as standards are concerned.

Schedule-IV
[Guideline 12(ii)]

Table.4 : Method for Disposal of Solid Waste

Sl.No.	Type of Waste	Category of Slaughter House	Method of Disposal
1.	Wastes consisting of inedible offals, animal tissue, organs, body parts, carcasses etc.	Large	Rendering
		Medium	Rendering or Controlled Incineration
		Small	Burial
2.	Stomach/intestinal contents, dungs etc.	All categories	Composting
3.	Sludge from wastewater treatment system	All categories	Composting

CHAPTER 6
INDUSTRIAL SOLID WASTE

6.1 INTRODUCTION

Environmental pollution is the major problem associated with rapid industrialisation, urbanisation and rise in living standards of people. For developing countries, industrialisation was must and still this activity very much demands to build self reliant and in uplifting nation's economy. However, industrialisation on the other hand has also caused serious problems relating to environmental pollution. Therefore, wastes seem to be a by-product of growth. The country like India can ill-afford to lose them as sheer waste. On the other hand, with increasing demand for raw materials for industrial production, the non-renewable resources are dwindling day-by-day. Therefore, efforts are to be made for controlling pollution arising out of the disposal of wastes by conversion of these unwanted wastes into utilisable raw materials for various beneficial uses. The problems relating to disposal of industrial solid waste are associated with lack of infrastructural facilities and negligence of industries to take proper safeguards. The large and medium industries located in identified (conforming) industrial areas still have some arrangements to dispose solid waste. However, the problem persist with small scale industries. In number of cities and towns, small scale industries find it easy to dispose waste here and there and it makes difficult for local bodies to collect such waste though it is not their responsibility. In some cities, industrial, residential and commercial areas are mixed and thus all waste gets intermingled. Therefore, it becomes necessary that the local bodies along with State Pollution Control Board (SPCB) work out requisite strategy for organising proper collection and disposal of industrial solid waste.

Management of Industrial Solid Waste (ISW) is not the responsibility of local bodies. Industries generating solid waste have to manage such waste by themselves and are required to seek authorisations from respective State Pollution Control Boards (SPCBs) under relevant rules. However, through joint efforts of SPCBs, local bodies and the industries, a mechanism could be evolved for better management.

In order to provide guidance to the local authorities some relevant information are provided under this Chapter so that a better understanding and awareness is created.

6.2 THE PROBLEMS

Assessment of industrial solid waste management problem greatly varies depending on the nature of the industry, their location and mode of disposal of waste. Further, for arriving at an appropriate solution for better management of industrial solid waste, assessment of nature of waste generated is also essential.

Industries are required to collect and dispose of their waste at **specific disposal sites** and such collection, treatment and disposal is required to be monitored by the concerned State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) in Union Territory. The following problems are generally encountered in cities and towns while dealing with industrial solid waste

- There are no specific disposal sites where industries can dispose their waste;
- Mostly, industries generating solid waste in city and town limits are of small scale nature and even do not seek consents of SPCBs/PCCs ;
- Industries are located in non-conforming areas and as a result they cause water and air pollution problems besides disposing solid waste.
- Industrial estates located in city limits do not have adequate facilities so that industries can organise their collection, treatment and disposal of liquid and solid waste;
- There is no regular interaction between urban local bodies and SPCBs/PCCs to deal such issues relating to treatment and disposal of waste and issuance of licenses in non-conforming areas.

6.3 INDUSTRIAL SOLID WASTE

The major generators of industrial solid wastes are the thermal power plants producing coal ash, the integrated Iron and Steel mills producing blast furnace slag and steel melting slag, non-ferrous industries like aluminum, zinc and copper producing red mud and tailings, sugar industries generating press mud, pulp and paper industries producing lime and fertilizer and allied industries producing gypsum.

Table: 6.1 Source and Quantum of generation of some major industrial waste

S. No	Name	Quantity (million tonnes per annum)	Source/Origin

1.	Steel and Blast furnace	35.0	Conversion of pig iron to steel and manufacture of Iron
2.	Brine mud	0.02	Caustic soda industry
3.	Copper slag	0.0164	By product from smelting of copper
4.	Fly ash	70.0	Coal based thermal power plants
5.	Kiln dust	1.6	Cement plants
6.	Lime sludge	3.0	Sugar, paper, fertilizer tanneries, soda ash, calcium carbide industries
7.	Mica scraper waste	0.005	Mica mining areas
8.	Phosphogypsum	4.5	Phosphoric acid plant, Ammonium phosphate
9.	Red mud/ Bauxite	3.0	Mining and extraction of alumina from Bauxite
10.	Coal washery dust	3.0	Coal mines
11.	Iron tailing	11.25	Iron Ore
12.	Lime stone wastes	50.0	Lime stone quarry

(Source : National Waste Management Council- Ministry of Environment & Forests-1990/1999)

6.4 DESCRIPTION OF IMPORTANT INDUSTRIAL SOLID WASTE

6.4.1 Coal Ash

In general, a 1,000 MW station using coal of 3,500 kilo calories per kg and ash content in the range of 40-50 per cent would need about 500 hectares for disposal of fly ash for about 30 years' operation. It is, therefore, necessary that fly ash should be utilised wherever possible to minimize environmental degradation. The thermal power plant should take into account the capital and operation/maintenance cost of fly ash disposal system as well as the associated environmental protection cost, vis-a-vis dry system of collection and its utilisation by the thermal power plant or other industry, in evaluating the feasibility of such system.

The research and development carried out in India for utilisation of fly ash for making building materials has proved that fly ash can be successfully utilised for production of bricks, cement and other building materials. Indigenous technology for construction of building materials utilising fly ash is available and are being practised in a few industries. However, large scale utilisation is yet to take off. Even if the full potential of fly ash utilisation through manufacture of fly ash bricks and blocks is explored, the quantity of fly ash produced by the thermal power plants are so huge that major portion of it will still remain unutilised. Hence, there is a need to evolve strategies and plans for safe and environmentally sound method of disposal.

6.4.2 Integrated Iron & Steel Plant Slag

The Blast Furnace (BF) and Steel Melting Shop (SMS) slags in integrated iron and steel plants are at present dumped in the surrounding areas of the steel plants making hillocks encroaching on the agricultural land. Although, the BF slag has potential for conversion into granulated slag, which is a useful raw material in cement manufacturing, it is yet to be practised in a big way. Even the use of slag as road subgrade or land-filling is also very limited.

6.4.3 Phosphogypsum

Phosphogypsum is the waste generated from the phosphoric acid, ammonium phospate and hydrofluoric acid plants. This is very useful as a building material. At present very little attention has been paid to its utilisation in making cement, gypsum board, partition panel, ceiling tiles, artificial marble, fiber boards etc.

6.4.4 Red Mud

Red mud as solid waste is generated in non-ferrous metal extraction industries like aluminum and copper. The red mud at present is disposed in tailing ponds for settling, which more often than not finds its course into the rivers, especially during monsoon. However, red mud has recently been successfully tried and a plant has been set up in the country for making corrugated sheets. Demand for such sheet should be popularised and encouraged for use. This may replace asbestos which is imported and also banned in developed countries for its hazardous effect. Attempts are also made to manufacture polymer and natural fibres composite panel doors from red mud.

6.4.5 Lime Mud

Lime sludge, also known as lime mud, is generated in pulp & paper mills which is not recovered for reclamation of calcium oxide for use except in the large mills. The lime mud disposal by dumping into low-lying areas or into water courses directly or as run-off during monsoon is not only creating serious pollution problem but also wasting the valuable non- renewable resources. The reasons for not reclaiming the calcium oxide in the sludge after recalcination is that it contains high amount of silica. Although a few technologies have been developed to desilicate black liquor before burning, none of the mills in the country are adopting desilication technology.

6.4.6 Waste Sludge and Residues

Treatment of industrial wastes/effluents results in generation of waste sludge/residues which, if not properly disposed, may cause ground and surface water pollution.

6.4.7 Potential Reuse of Solid Wastes

Research and Development (R&D) studies conducted by the R&D Institutions like Central Building Research Institute, Roorkee (CBRI) and the National Council for Building Research, Ballabgarh (NCBR) reveal that the aforesaid solid wastes has a very good potential to be utilised in the manufacture of various building materials.

6.5 WASTE MANAGEMENT APPROACH

A two-tier approach should be thought of for waste management, e.g., (a) prevention & (b) control of environmental pollution. Prevention aims at minimisation of industrial wastes at source, while the latter stresses on treatment and disposal of wastes. A schematic diagram of waste management is shown in Fig.6.1.

6.5.1 Prevention- A Waste Minimisation Approach

Reduction and recycling of wastes are inevitably site/plant specific. Generally, waste minimisation techniques can be grouped into four major categories which are applicable for hazardous as well as non-hazardous wastes. These groups are as follows :

Inventory Management and Improved Operations

- Inventorisation and tracing of all raw materials ;
- Purchasing of fewer toxic and more non-toxic production materials ;
- Implementation of employees' training and management feedback ; and
- Improving material receiving, storage, and handling practices.

Modification of Equipment

- Installation of equipment that produce minimal or no wastes ;
- Modification of equipment to enhance recovery or recycling options;
- Redesigning of equipment or production lines to produce less waste ;
- Improving operating efficiency of equipment ; and
- Maintaining strict preventive maintenance programme.

Production Process Changes

- Substitution of non-hazardous for hazardous raw materials ;
- Segregation of wastes by type for recovery ;
- Elimination of sources of leaks and spills ;
- Separation of hazardous from non-hazardous wastes ;
- Redesigning or reformulation for products to be less hazardous; and
- Optimisation of reactions and raw material use.

Recycling and Reuse

- Installation of closed-loop systems ;
- Recycling off site for use ; and
- Exchange of wastes.

Waste minimisation at source may be achieved within the industry through application of various approaches described above. The systems for waste minimisation, utilisation and recycling are schematically shown in Fig. 6.2.

6.5.2 Waste Management at Source

A specific example worth-mentioning in this context is removal of fly ash through coal beneficiation process at the mine head in view of high ash content. It is evident that the larger the volume of waste and the longer the distance of transportation of raw material (coal), the bigger will be the economic benefit in favour of coal beneficiation instead of carrying the filthy fly ash. However, benefit-cost analyses have to be made before taking appropriate decision.

6.5.3 It is possible to cut down waste generation at source by simple, inexpensive measures modifying production processes, through changes in raw materials/product design and by employing recovery/recycling and reuse techniques (Fig.6.3)

6.5.4 To avoid treatment through utilisation of waste, it is important from the environmental pollution view point as well as for the benefit of entrepreneurs to recycle and reuse the wastes generated by adoption of certain process change or by use of low/no-waste generation technology.

6.5.5 Waste minimisation can be practised at various places in the industrial processes. Waste minimisation requires careful planning, creative problem evolving, changing in attitude, some times capital investment, and most important a real commitment. More often than not, investment on waste minimisation and recovery pays off tangibly within a short time. Such studies have been conducted and results are provided in Table 6.2.

TABLE: 6.2 Investment on Waste Minimisation and Recovery

Industry	**Total waste-water flow(Cubic metres per day)**	**Total cost of plant (Rs. in thousand)**	**Net annual recovery (Rs. in thousand)**	**Investment pay back period (yrs)**	**Remarks**
Textile Industry	6,450	4,625	4,375	1.05	Recycle in process house
Alcohol Industry	1,725	2,250	975	2.30	Reuse of energy in process house
Food Processing	1,460	10,500	4,250	2.47	Recycling for irrigation/ process house and reuse of energy
Viscose Rayon	4,500	200	36	5.5	Recovery and reuse of zinc. Foreign exchange saving.
Cement Industry (1200 t.p.d. production capacity)	-	3,44,000	2,24,000	1.50	Recovery & reuse of cement and clinker dust.

(Source : Industrial Waste Management, NWMC, 1990)

6.5.6 The initial investment for a pollution prevention project may be higher in some cases than the cost of installing conventional pollution control equipment. However, the annual operation and maintenance cost of the removal will almost always make the total cost of treatment higher than the total cost of preventive measures at sources. However, treatment and disposal of residual waste even after taking preventive measures should be given due consideration.

6.6 AREA OF APPLICATION OF SOME IMPORTANT INDUSTRIAL WASTES

S.No.	Waste	Areas of Application
1.	Flyash	i. Cement ii. Raw material in Ordinary Portland Cement(OPC) manufacture iii. Manufacture of oilwell cement. iv. Making sintered flyash light-weight aggregates. v. Cement/silicate bonded flyash/clay binding bricks and insulating bricks. vi. Cellular concrete bricks and blocks, lime and cement fly ash concrete. vii. Precast flyash concrete building units. viii. Structural fill for roads, construction on sites, Land reclamation etc. ix. As filler in mines, in bituminous concrete x. As plasticiser xi. As water reducer in concrete and sulphate resisting concrete xii. Amendment and stabilisation of soil.
2.	Blast Furnace Slags	i. Manufacture of slag cement, super sulphated cement, metallurgical cement. ii. Non-portland cement ii. Making expansive cement, oilwell, coloured cement and high early-strength cement. iv. In refractory and in ceramic as sital v. As a structural fill (air-cooled slag) vi. As aggregates in concrete.

3.	Ferro-alloy and other metallurgical slags.	i. As structural fill ii. In making pozzolana metallurgical cement
4.	By product gypsum	i. In making of gypsum plaster, plaster boards and slotted tiles ii. As set controller in the manufacture of portland cement iii. In the manufacture of expensive or non-shrinking cement, super sulphated and anhydrite cement iv. As mineraliser v. Simultaneous manufacture of cement and sulphuric acid
5.	Lime sludge (phos-phochalk, paper and sugar sludges)	i. As a sweetener for lime in cement manufacture ii. Manufacture of lime pozzolana bricks/ binders iii. For recycling in parent industry iv. Manufacture of building lime v. Manufacture of masonry cement
6.	Chromium sludge	i. As a raw material component in cement manufacture ii. Manufacture of coloured cement as a chromium-bearing material
7.	Red mud	i. As a corrective material ii. As a binder iii. Making construction blocks iv. As a cellular concrete additive v. Coloured composition for concrete vi. Making heavy clay products and red mud bricks vii. In the formation of aggregate viii. In making floor and all tiles ix. Red mud polymer door
8.	Pulp & Paper	i. Lignin

(Source : Industrial Waste Management, NWMC, 1990)

6.7 CURRENT PRACTICE OF INDUSTRIAL SOLID WASTE MANAGEMENT

6.7.1 Collection and Transport of Wastes

Manual handling of industrial waste is the usual practice in developing countries; there are very few mechanical aids for waste management. Wastes are shovelled by hand into storage containers and loaded manually into lorries. The people undertaking salvaging do so mainly by hand, picking out useful items, usually not even wearing gloves. Although there may not be a health risk in handling clean waste paper, people handling or salvaging waste without protective clothing are at risk when waste is mixed with chemicals. Apart from the likelihood of cuts caused by broken glass or sharp metals, sorting through waste contaminated with hazardous chemical materials could cause skin burns, excessive lacrimation, or even loss of consciousness; chronic hazards include respiratory problems from dust inhalation, and potential carcinogenicity from toxic chemicals present in discarded containers or surface deposits in other waste. Personnel handling waste from tanneries or hide processors may also be exposed to such diseases as anthrax. Necessary precautions will reduce and minimise hazards associated with manual handling of industrial wastes. Personnel handling hazardous wastes should wear appropriate protective clothing. Mechanical methods for handling waste should be adopted wherever possible, and people should be educated about the dangers of manual handling of hazardous waste.

6.7.2 Storage & Transportation

The storage of industrial solid waste is often one of the most neglected areas of operation of a firm. Very little attention is paid to proper storage and heaps of mixed waste piled against a wall or on open ground are a common sight in many factories. Concrete bays or disused drums are also often used for storage. Whereas the sludges originating from holding tanks or interceptors do not present storage problems as no separate sludge storage is required, because the sludge is retained in the tank until sufficient quantities are collected.

Waste is rarely covered, protected from vermin or pretreated in any manner. There are no restrictions on access and employees are often encouraged to sort out through such wastes and take away any useful material or articles they find. Waste is regarded as an unwanted product by firms and very often no senior person is assigned for its control.

Transportation of industrial waste in metropolitan areas of developing countries is generally not by purpose-built vehicles such as skip-carrying lorries, but by open trucks. The wastes are not covered during transportation. It is typical for a firm not to have any standing arrangements with one contractor, but to allow collection by whoever is the contractor quoting lowest rates. It is rare for special arrangements to be made for hazardous wastes; they are usually collected together with the other wastes. Contractors who carry hazardous waste do not need to be licensed, and consequently, there is little control over either the types of firms engaged in carrying hazardous waste or the vehicles used. Drivers are not given a list of precautions to be taken; there is no manifest or labeling system of wastes during transport. Fly-tipping is often prevalent and wastes are often taken to disposal sites inappropriate for the type of waste concerned.

6.7.3 Disposal of Industrial Solid Waste

Industrial waste, whilst presenting the same disposal problems as domestic waste, also contains hazardous waste, thereby exacerbating the difficulties of disposal. Fortunately, the types of industrial wastes generated in a municipal area of a developing country are such that there are not usually large quantities of particularly hazardous wastes for disposal. In the past there has been little control over the disposal of industrial wastes; indeed, it has only been during the last decade that even developed countries have brought in legislation to curb the uncontrolled and environmentally unacceptable practices that were widespread. Without such legislation disposal is almost always by uncontrolled landfill at sites which often pose a threat of water pollution due to leachates.

6.8 HEALTH CONSEQUENCES OF POOR INDUSTRIAL WASTE DISPOSAL

The solid waste generated from industrial sources contains a large number of chemicals, some of which are toxic. The waste is considered toxic, if the concentration of the ingredients exceeds a specified value. Although the levels of some ingredients may occasionally exceed the permissible level, the waste as such is considered to be toxic only if the average value of ingredients exceeds the toxicity level. Various criteria and tests have been devised by different agencies to determine the toxicity of a given substance. It is necessary to know the properties of the waste so as to assess whether its uncontrolled release to the environment would lead to toxic effects on humans or other living organism in ecosystem. This evaluation is carried out using criteria such as toxicity, phytotoxicity, genetic activity and bio-concentration. The potential toxic effects also depend on quantity of the toxic constituents. Substances are classified as hazardous or otherwise depending on the dose, exposure, and duration of exposure. For a chemical to affect human health it must come in contact with or enter the human body. There are several ways in which this can happen.

Skin contact :Chemicals that cause dermatitis usually do so through direct contact with skin. Some chemicals like corrosive acids can damage the skin by a single contact while others, like organic solvent, may cause damage by repeated exposure.

Inhalation : Inhalation is the most common source of workplace exposure to chemicals and the most difficult to control. Air pollutants can directly damage respiratory tract or gets absorbed through lung and cause system/systemic effects. An adult male will breathe about 10 cubic meters of air during a normal working day.

Ingestion : Ground water and sub soil water contamination from leachates from refuse dumps and poorly managed landfill sites can result in ingestion of toxic chemicals by population groups who live far away from the factory sites and decades after the garbage has been dumped.

There are very few studies conducted in India on specific health problems resulting from accidental exposure to toxic industrial solid waste. There had been reports that sacks, cardboard cartons and paper envelopes contaminated with chemicals packed in them were burnt and the irritating fumes from these caused respiratory problems. There had also been reports of skin or respiratory irritation following exposure to corrosives chemicals. There has been no efforts to systematically investigate and obtain reliable epidemiological data on health consequences of exposure to hazardous industrial wastes in different States.

Wastes from slaughter house is potentially infectious. All precautions to ensure that potential pathogens to not gain a foot hold in the workers in the slaughter house and in the general population, have to be taken during collection, storage and disposal of the slaughter house waste.

Wastes from non hazardous industries can at times produce health problems, not only among the workers and handlers of waste, but also among general population. One example of this category is the cotton dust. Cotton waste are generally non hazardous; however they may, in susceptible individuals provoke respiratory allergic reactions; allergy may be due to inhalation of dust containing cotton wastes or fungus or other contaminants in the waste dust.

6.9 COLLECTION, STORAGE TREATMENT & DISPOSAL OF WASTES

6.9.1 Waste Segregation

Many wastes are mixtures of hazardous and non-hazardous wastes. Much of their contents may even be water. By segregating key toxic constituents, isolating liquid fraction, keeping hazardous streams away from non-hazardous wastes, generator can save substantial amounts of money on disposal or find new opportunities for recycling and reuse of wastes. The Ministry of Environment, Government of India, had identified toxicity of different chemicals, through the 'Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989' in exercise of power conferred by Section 6, 8 and 25 of Environment Protection (E.P). Act, 1986, and had notified mandatory requirements for its management. In India quantum of generation of wastes (solid/liquid and hazardous/non-hazardous) for different industry has not been detailed, which is necessary for wastes exchange system or for adopting treatment/ disposal alternatives for different wastes segregated.

6.9.2 Collection, Storage and Transport

The unsatisfactory state of storage of hazardous wastes can be remedied to a large degree by such low-cost measures as restricting access, fencing off the storage area to minimise any wind-blown nuisance, providing separate covered storage for putrifiable of hazardous wastes, and ensuring regular and frequent collection.

There are certain measures a municipal authority can take to control the transportation of industrial wastes, even if it does not want to become actually involved itself. For instance, contractors should be licensed after ensuring that they are technically competent and environmentally aware and should be allowed to handle industrial wastes. Labeling and coding of hazardous waste load can be made mandatory so that in the event of an accident, the emergency services know how to handle a spillage. Municipal authorities can be given the responsibility to monitor the contractors to minimise cases of fly-tipping and ensure that industrial wastes are disposed at the appropriate sites. If a municipal authority can also collect industrial waste; industries must pay the charge which will be based on the quantity and nature of the waste. This might minimise the quantity of waste produced by industry and at the same time the programme will become financially viable and self sustaining. The principle 'the polluter pays' should be adhered to in all such cases.

6.9.3 Combined Treatment Facilities

Small-scale industries, which contribute about more than half of the total production, also generate huge quantity of wastes. The small-scale industries are not in a position to treat their solid wastes or liquid effluent because of space, technical know-how and financial constraints. It is, therefore, deemed that in a cluster of small-scale industries the different wastes are characterized, identified, quantified and stored for treatment through a combination of recycling, recovery and reuse of resources such as, raw material, bio-gas, steam and manure, besides providing an efficient service facility, to make the system less expensive. The combined effluent treatment plants (CETP) are to be operated by the local bodies, where the cost of construction, operation and maintenance need to be shared by individual industries depending upon the quality and quantity of wastes generated. However, such common treatment facility may require pre-treatment at individual industry to the extent specified by the State Pollution Control Board. With regard to availability of wastes along with their identification, quantum of waste generated should also be ascertained so that technology development/adoption can be considered on economic grounds for a small-scale or organised sector of industry. If economics justify movement of wastes over longer distances for a centralised plant, specific subsidies for storage, collection and transportation could be considered. The flow chart for waste collection centre is shown in Fig.6.4.

CETPs are being successfully operated in Gujarat and Andhra Pradesh and such facilities should be promoted in other States. A typical wastewater segregation and treatment system in an industrial estate is depicted in Fig. 6.5

Small scale industries having waste characteristics similar to those of near by large industry having waste treatment facilities can take help in treating their wastes on payment basis.

6.9.4 Disposal Methods

Depending upon the characteristics of the wastes, different types of disposal methods can be used for hazardous and non-hazardous industrial wastes. The most predominant and widely practised methods for wastes disposal are : (a) Landfill, (b) Incineration and (c) Composting.

For thousands of years, man has disposed the waste products in a variety of ways, the disposal method might reflect convenience, expedience, expense, or best available technology. There were no major ecological or health hazards associated with these practices until the last century. Explosive increase in the amount of

chemical waste produced and the indiscriminate dumping of hazardous industrial waste in the last few decades has created health and ecological crisis in many areas of the world. In many instances, leachate from the wastes dumped by one generation haunts the later generation in the form of ground water and subsoil water contamination. The recent discovery of volatile organic chemicals from landfills and industrial disposal ponds is disturbing because many of these chemicals are known or suspected carcinogens and are not removed easily by natural geochemical processes. The risk of the contamination of groundwater supplies due to leachates from landfills depends on several factors; toxicity and volume of the contaminant generated at each site, the nature of the geologic medium underlying the site, and the hydrologic conditions dominant in the area.

In the past, the least expensive and most widely used waste management option for both municipal and industrial waste has been the sanitary landfill, where wastes are compacted and covered with earth. In any geographic area other than arid zones, the fill is subjected to percolating rainwater or snowmelt which eventually flows out from the bottom of the landfill site and moves into the local groundwater system. Leachate is a liquid that is formed as infiltrating water migrates through the waste material extracting water-soluble compounds and particulate matter. The mass of leachate is directly related to precipitation, assuming the waste lies above the water table. Much of the annual precipitation, including snowmelt is removed by surface run off and evaporation; it is only the remainder that is available to form leachate. Since the landfill covers to a large extent and controls leachate generation, it is exceedingly important that the cover be properly designed, maintained and monitored in order to minimise leachate production. Fortunately, many substances are removed from the leachate as it filters through the unsaturated zones, but leachate may pollute groundwater and even streams.

These leachates, can contain large amount of inorganic and organic contaminants. At some sites, the leachate is collected and treated. But even in the best engineered sites, some leachate escapes into the groundwater system because no permanent engineering solution has been found to isolate the leachate completely from the groundwater.

It is now recognised that the interaction between leachate and soil are actually very complex and depend both on the nature of soil and on the leachate. When leachate percolates through solid wastes that are undergoing decomposition, both biological materials and chemical constituents are picked up. Recent research in the United Kingdom (U.K) has, however, shown that chemical and biological phenomena in landfill such as microbiological process; neutralisation; precipitation and complexion; oxidation and reduction; volatilisation; adsorption reduce the quantity and quality of polluting leachate from landfill site and achieve some degree of on-site treatment or immobilisation. In spite of all these, the leachate often pose severe disposal problem at a landfill site. Two of the most economic but efficacious purification methods are spraying over grassland or percolation through an aerobic bed of sand or gravel.

In general, it has been found that the quantity of leachate is a direct function of the amount of external water entering the landfill. In fact, if a landfill is constructed properly, the production of measurable quantities of leachate can be eliminated. When sewage sludge is to be added to the solid wastes to increase the amount of methane produced, leachate control facilities must be provided. In some cases leachate treatment facilities may also be required.

The pollution of static water ditches, rivers or the sea can occur when a sanitary landfill adjoins a body of water. The normal source of the leachate causing this pollution is rain falling on the surface of the fill, percolating through it, and passing over an impermeable base to water at a lower level. The quantity of leachate can be substantially increased when upland water drains across the site of the landfill, but the worst case is when a stream crosses the site. The solutions to these problems lie in appropriate site engineering such as :

(i) diversion or culverting of all water courses which flow across the site,

(ii) diversion of upland water by means of drainage ditches along appropriate contours,

(iii) containment of leachate arising from precipitation by the construction of an impermeable barrier where necessary, such as a clay embankment adjoining a river,

(iv) grading the final level of the site so that part of precipitation is drained across surface, thereby reducing percolation below the level needed to produce a leachate.

Works of this nature will obviously add to the cost of a sanitary landfill project. However, when capital expenditure is spread over the life of the project, the cost/ton of waste disposed might be less than for any alternative method of disposal. Furthermore, some of these forms of expenditure, such as culverts or river walls, represent capital assets of continuing value when the reclaimed land is handed over for its final use, perhaps for agriculture or recreation.

Incineration of hazardous industrial waste has been advocated in developed countries. Guidelines for safe incineration of hazardous chemical waste have been drawn up by United States Environmental Protection Agency. Incineration of hazardous waste is a process requiring sophisticated expensive incinerators and a high degree of technological expertise for satisfactory operation. The capital cost of incinerator is high, especially if it is intended for hazardous wastes and gas scrubbing equipment is required. Some wastes such as oils and organic solvents can be readily treated by incineration. If financial constraints come in the way of purchasing sophisticated incinerators then the utilisation of open pit incinerator under careful technical supervision can be considered as an option.

6.9.4.1 Landfill

The owner or operator of a facility must follow the design and operating criteria stipulated by the regulatory agencies. However, depending upon the characteristics of the waste, the landfill system with leachate collection system has to be designed with necessary facility for ground water quality monitoring.

The common centralised facility of the operating agency is likely to consist of land-fill type of disposal and hence, it will be worthwhile to know certain definitions to begin with.

(i) Definitions:

- **Disposal** is the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water, so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

- **Land disposal** is defined to include, but not limited to, any placement of hazardous waste in a landfill, surface impoundment, waste-pile, injection well, land treatment facility, salt dome formation, or underground mine or cave. It can also consider placement of hazardous wastes in concrete vaults or bunkers intended for disposal purposes as methods of waste management subject to certain restrictions. However, it does not include and permit open burning on land and detonation.

- **Landfill** means a disposal facility or a part of a facility where hazardous waste is placed in or on land and is not a land treatment facility, a surface impoundment or an injection well. Landfill cell means a discrete volume of a hazardous waste landfill that uses a liner to provide isolation of wastes from adjacent cells or wastes. Examples of landfill cells are trenches and pits.

- **Land treatment facility** means a facility or part of a facility at which hazardous waste is applied onto or incorporated into the soil surface, such facilities are disposal facilities if the waste will remain after closure.

- **Surface impoundment** means a facility or part of a facility that is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), that is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and that is not an injection well. Examples of surface impoundments are holding, storage, setting and aeration pits, ponds and lagoons

(ii) Why landfills?

While new methods of hazardous waste disposal are being developed, it appears that landfills will, at least for the time being, continue to be the most favoured technique. In many countries, land is a readily available commodity and often areas of non- productive or derelict land may be made available for waste disposal. In many instances, land can be utilized in the near vicinity or on the premises of industrial companies, thereby reducing transportation costs. The potential also exists to reclaim certain areas for recreational purposes.

Landfilling is still the major disposal method in many countries. Yet in many instances landfilling sites are not properly chosen in terms of geophysical soil properties, hydrogeology, topography and climate. On a proposed site there is a need to carefully consider the potential for ground or surface water contamination from pollution by leachate migration or surface run-off from the site. Nonetheless, even when a site appears to have the right geophysical properties, its selection and use are not an absolute guarantee that contamination of groundwater can be avoided. Hence, continuous surveillance of the site and its surroundings must be maintained to check that the disposal of hazardous wastes can continue without posing a threat to the environment and to the general public. To reduce this threat landfill sites have been lined, for example with plastic materials, in order to prevent leaching into groundwater supplies.

(iii) Design:

While preparing the lay-out of a land-fill site, it may be seen that it comprises at least the following units, viz.

I. Vehicle weigh bridge
II. Vehicle and instrument work-shop
III. Laboratory for sample analysis
IV. Operational area
V. Operational building with amenities
VI. Control systems
VII. Illumination, roads, fencing, trenches etc.

The principle objective of a hazardous waste landfill is to isolate the waste materials within a confined area and prevent uncontrolled leakage of liquid contaminants. Design of the facility, therefore, requires provisions for an impermeable liner, a leachate collection and treatment system, and a suitable cover that is resistant to erosion and rainwater infiltration.

In certain situations, hazardous wastes may be disposed of in landfills under semi-controlled conditions. Co-disposal of hazardous wastes with domestic refuse, demolition waste, fly ash, municipal waste and inert industrial wastes in unlined landfills has, for example, been widely practised in the U.K. for many years. Co-disposal is advantageous from the point of view of enhanced neutralisation, detoxification and stabilisation of the waste pile. Where suitable soils exist, attenuation of waste leachate from waste piles is restricted to a relatively small area, thus reducing the potential for ground water contamination.

The Ministry of Environment & Forests (MoEF) guideline of 1991 has suggested a double liner system with synthetic or clay liner for landfill (two designs) as shown in Fig. 6.6

CASE STUDIES

(i) In a German experience, a company found the following arrangement satisfactory. The controlled dumps run by the company have a multiple seal to protect the groundwater. The bottom layer of this seal consists of in-situ or specially deposited and compacted clay forming a 50 cm-thick impermeable layer. To compensate for unevenness in the clay layer, a 10 cm sand layer is spread on top and lined, in turn, with 3 mm-thick, elastic polyethylene sheet, forming a second water-tight layer. This is covered by 30 cm of gravel which takes up the leachate from rainwater or from moist sewage sludge in the dump and channels it to the wastewater treatment plant through a system of drainage pipes. On top of this gravel layer is a 70 cm covering of soil and slag. On this layer the waste itself is deposited. During the period of use, i.e. while waste is still being deposited, the dumps look like enormous troughs. On completion of the controlled dump- when it has reached its projected size- the hill is sealed with an impermeable covering. By planting vegetation and by other measures the hill becomes integrated into the surrounding landscape. The groundwater in the vicinity of all the controlled dumps is required to be carefully monitored. The dumps are surrounded by observation wells. The water from these wells is regularly analysed.

(ii) Another secure landfill site in Bavaris (Germany) has following features.
Clay pad construction

- depth of pads : 60 cm
- permeability : 10 cm/sec
- Depth of sidewalls : 60 cm
- Final cover : 0.75 metres

Water-soluble solid wastes containing heavy metals are deposited in drums and covered with concrete to reduce the contamination in the leachate. In addition to daily cover, a plastic membrane is intermittently placed over completed lifts to reduce infiltration. A hand operated vibrator is also utilised to compact daily cover in an effort to reduce the volume of leachate generated.

Leachate is collected by a series of under-drains, located in the clay pad. Leachate is then channeled to a plastic lined (3 mm) retention pond from where it is trucked.

The United States Environmental Protection Agency has published regulations. These regulations, implemented primarily in the interests of protecting groundwater resources and the longer-term security of facilities, requires that all new landfills be constructed with a leachate collection system and a liner that is capable of preventing migration of leachate throughout the operational life of the facility. Preference is given to synthetic liners. Unless facilities are constructed with a double liner system with a leak detection system between the liners and a leachate collection system at the base of the landfill (figure 6.7), groundwater has to be monitored both upstream and downstream of the site. At closure, the construction of an impermeable cap is required and maintenance of the facility must be continued throughout the period specified in the permit, which in most cases will be about thirty years.

The operating agency in Indian context, shall take cognizance of all the above experiences and derive a good formula for themselves. Such reasoned communication be submitted to the SPCBs while obtaining an Authorisation. In case any new developments come up, the operating agency should keep an eye on it and adopt the same.

(ii) Construction:

The landfill should be as secure as possible, because hazardous waste howsoever treated, lies there as a tickling time-bomb. New construction materials are getting developed everyday. These improved techniques be followed. Before going in for construction, the operating agency should first do a complete geological survey of the property to look for fissures, determine the depth of bed rock, check the percolation rate, and other pertinent factors. Any landfill construction be at least 3 m above groundwater or as may be directed and above the 100 year floodplain. All this compiled data along with proper drawings should be submitted to SPCBs and got approved. They may have any new suggestion. If a 3 m of packing clay is to be put at bottom, it should be placed in 20 layers of 60 mm each by using such clay which has grains long and flat, and layers are continuously compacted to form a very tight, impermeable barrier. This should be checked on Proctor's scale. On the clay blanket, is spread a polyethylene high density sheet welded to each other and weld tested thrice. Once the synthetic liner has been installed, another 300 mm clay is sprayed and compressed on the same. This layer protects the liner and works as third barrier too. On top, there is kept a layer of crushed stone to aid leachate collection and this is a place to house the leachate collection pipe system, described in others experiences.

The operating agency is better advised to report to SPCB if there is any change made in their facility after obtaining authorisation, even minor such as replacement of liner or change in crop pattern.

The operating agency, should not make an oversimplification that landfill is a panacea and any hazardous waste can be dumped into it. A treatment in most cases is necessary and landfill at best can serve as a mode of disposal thereafter, like Poly Chlorinated Biphenyles (PCBs), Halogenated Organic Compounds (HOC), other wastes, and free liquids (unless they are first solidified).

(iii) Closure & Post Closure:

The operating agency has a limited land area, on which he is doing his activities of hazardous waste treatment and disposal. This limited area will eventually get filled and then he will have to close the present establishment carefully and go somewhere else. The closure is a period after which wastes are no longer accepted and during which the owner or operator completes all treatment, storage or disposal operations. Partial closure is also possible. The purpose of the closure standards is to ensure that all hazardous wastes management facilities are closed in a manner that to the extent necessary (i) protect human health and the environment; and (ii) controls, minimises or eliminates post-closure escape of hazardous waste, hazardous constituents, leachate or contaminated rain run-off or waste decomposition to the water, air or soil. If the site is housefull, then it is called as closure, but if due to mismanaged leachates and groundwaters pollution, activity is forced to be stopped, then it is not closure it is abandoning the site.

The operating agency while developing its first application for Authorisation has to plan as to in what time period, the accommodation provided by him will be put. Depending on what type of waste he is transporting in, he will have to imagine a closure plan. It should contain

(1) A description how each of his unit in the facility will be closed.

(2) A description of how final closure of the entire facility will be conducted.

(3) An estimate of the maximum inventory of hazardous wastes on site at any time during the active life of facility

(4) A description of the steps needed to remove or decontaminate all hazardous waste residue

(5) A sampling and analysis plan to know as to how much decontamination will be necessary

(6) A time-table of commencement of closure prospects and completion.

The operating agency should prepare a closure plan on paper at least 6 months in advance so that opinion of the SPCB can be obtained. It is better to complete the closure as per plan speedily, but not hastily. A period of 3 months to 6 months from the SPCB approval should prove adequate.

There can be two options for closure. In one, the residues, spent liners etc. are removed and shifted from the place and in another, the residues are left in place and operating agency taking its post-closure precautions. The post closure care is to:

(1) Eliminate all free liquids by either removing the liquid wastes/residues from landfill/impoundment of by solidifying them

(2) Stabilise the remaining waste and waste residues to a bearing capacity sufficient to support a final cover.

(3) Install a final cover that provides long- term minimisation of infiltration into the closed unit

(4) In course of time, the material inside a landfill is likely to face settling or subsidence in a small way. The cover be such that all such subsidence of support, it should not get cracked, but its integrity be maintained.

(5) Provide drainage diversions to prevent any run-on

(6) To grow an appropriate vegetation on the top of the cover.

The operating agency should submit a certificate of completion of closure and post-closure to the State Boards.

The operating agency must remember that money is required not only for establishing or for running a facility, but the closure too costs money. Therefore, provision of funds should be made during the process or insurance may be purchased during operating life, that assures funds for closure and post closure care.

6.9.4.2 Incineration

Depending upon the categories of waste and its potential hazards, following incineration methods are adopted :

i. Destruction of hazardous waste by thermal process using incinerator or any other method; and

ii. Burning of hazardous waste in boiler or in industrial furnace in order to destroy them and/or for any recycling purpose and/or energy source.

The first category of incinerator requires special attention. In India there are very few incinerators installed on a large scale. It is important to have a central incinerator facility in the remote areas of different regions for incinerating hazardous wastes which may be operated by a corporate body. However, before taking a step in burning hazardous wastes through incinerator it is essential to stipulate standards to be achieved after incinerating such material. The hazardous wastes in the region to be treated can be centrally collected and transported to the facilities. In this process of central facility of treatment, the polluter has to pay for treatment facility depending on the quantity and quality of wastes generated.

In the second category of incineration, there are a number of cement industries and thermal power plants where the wastes can be burnt after considering the nature and quantity of wastes. However, in this case it is to be seen that the gaseous emission through stack does not affect the ambient air quality adversely.

The operating agency will find that the incineration is a costly alternative, but sometimes it is the only alternative. It reduces the volume of waste requiring the landfill capacity, is suitable for most clinical, commercial and house-hold wastes, is the only suitable disposal option for certain waste (practical or legal point of view) and can recover heat system.

Incinerator means any enclosed device using controlled flame combustion. In designing an incinerator the operating agency should take into consideration the thermal feed rate, waste feed rate, organic chlorine feed rate (where relevant), minimum combustion gas temperature, minimum combustion gas residence time, primary and secondary combustion units, removal of Hydrochloric acid (HCl), Suspended Particulate Matter (SPM) and other air pollutants, minimum oxygen concentration in secondary chamber, controlling fugitive emissions (by keeping combustion zone totally sealed or by maintaining the combustion zone pressure negative), stack height, eventuality of alternative fuel, eventuality of change in waste containing Principal Organic Hazardous Constituent (POHC). The operating agency should convey these criteria to the SPCBs for any comments and if there is any change subsequently in the gadget or geometry, the same too must be informed or authorisation got so amended. This will enable them to take a new trial burn if necessary.

Incineration is not an open burning. Open burning means the combustion of any material without the following characteristics :

(1) Control of combustion air to maintain adequate temperature for efficient combustion

(2) Containment of the combustion reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion

(3) Control of emission of the gaseous combustion products as per regulations.

Open burning on land is not a method for disposal as it does not have a status of either incinerator or landfill. The operating agency should assure the SPCBs that they will undertake only controlled method and it is open for their inspection any time of combustion, emissions, attendant units (like pumps valves, conveyors) or housekeeping.

In general, industrial incinerators comprise a storage pit, fuel tanks, a furnace (generally of a rotary kiln type), a heat recovery boiler, off gas purification [possibly a scrubbing water treatment unit, and even Electro Static Precipitator (ESP) in good installations], an induced draft (ID) fan, a reheating unit (if necessary) and a stack (incidentally, even co-generation is possible).

In a reported experience of Bayer, AG, Germany, the plant temperature in rotary kiln is maintained at 1000-1200^{0}C , with oxygen concentration kept at 11% by volume, and detention of 4 seconds. The detention is 18 seconds in after burner chamber. In the waste heat recovery boiler, the temperature comes down to 320-350^{0}C, the HCI, SO_2 is washed down. PCBs are found destroyed. The flow-sheet is shown in figure 6.9 which may encourage the OA to put up an incineration train on such sound footing.

If the operating agency desires to get rid of organics like halogenated solvents, petroleum refinery waste, vinyl chloride monomer, plastics, pesticides, off-spec pharmaceuticals etc. with a chemical destruction efficiency of 99.99%, then incineration will be his only choice, regardless as to whether he feeds as gas, liquid, semi-solid, or solids.

Operating agency has to put only selected crew to run this unit as the precautions are necessary at every place right from unloading the incoming tankers (preferably with nitrogen blanket), segregated storing as per high or low British Thermal Unit (BTU) value. Some, if arriving in a mixed form, has to be sent to a specific gravity based separators through vibratory screen, as also a separate storage for high or low pH wastes. This helps in blending, because the success of operating agency's incinerator cannot be ensured, if the feed is non-uniform in quality and quantity. In this system, organics are destroyed and the inorganics are converted. The clays, dissolved salts or silica are released within the incinerator flue gas and the same ash is required to be trapped and then disposed of in the landfill. The volume reduction be estimated and recorded. The operating agency should also record the temperatures at various points (actual against designed) such as say (1) initial temperature in the primary chamber 1400^0 C, (2) after injecting aqueous waste as 800^0 C, (3) after passing through scrubber/ spray dryer, (4) after fabric filter 200^0 C in the stack. In the stack, the emission monitoring be done for levels of oxygen, unburnt hydrocarbons, sulfur dioxide and opacity (- a measure of particulate matters going up the stack) and record the same, in computer. The residence time in seconds also be recorded.

The operating agency should keep a safety and security in its plant to boast that nothing moves in the premises without permission, even the rain water (which is collected as run-on, analysed, pH adjusted or settled and then pumped run to allow it out).

6.9.4.3 Manifest System

In the management of solid and liquid industrial wastes it is very important to incorporate a manifest system by which the chain responsibility of generator, carrier and receiver is to be realised. This system will help the regulatory agency as nodal agency, where finally the copy of the manifest will be sent, to know whether the actual wastes generated are transported to the facilities where it is to be disposed off. In this process of waste management, all the three, viz. pollution generator, carrier and receiver, will have to take authorisation from the nodal agency. It is felt that in India also for the management of industrial wastes, whether they are hazardous and non-hazardous, a manifest system has to be framed to identify what category of waste has to be transported for disposal and treatment. The schematic sketch of such a system is shown in Fig.6.8.

6.9.4.4 Post Treatment

The post treatment precautions to be undertaken by the operating agency depend much on what treatment he has offered to the subjected hazardous waste. The treatment given to the waste shall be complete and not half-way.

If physico-chemical-biological treatment is successfully given, the outgoing post-treatment streams will be three fold. The oil may be sold or sent for incineration, the sludge after dewatering be sent to secure landfill and the water after analysis may join a stream on permission from the SPCB or may be used on adjoining land by irrigation. Operating agency to maintain a full record.

If the treatment-disposal is a secured landfill, if post-treatment leachate appear, the same be collected and recycled into the operating agency’s facility for re-treatment. One will find that leachate exhibits very high polluting and hazardous characteristics.

If incineration or thermal treatment is adopted, the captured post-treatment ash be sent for burial and scrubber water be sent back into the facility for treatment. Operating agency at every step should maintain a computerised record.

If recovery is a treatment method, it converts a hazardous waste into a non-hazardous non-waste. This post-treatment, is acceptable to the customers and can be so sold. It may be a hazardous chemical, but no more a hazardous waste.

6.9.4.5 Back-transport

There can be only three types of back-transport. Number one, where there is a manifest discrepancy, number two where the waste sent by generator to operating agency facility is not as per contract and number three, when a renovated material after recovery returns back to a customer. The former two be avoided, while the third one is a welcome step.

It will be a good practice if the operating agency keeps a discipline of collecting the waste by himself from the generators' premises. Operating agency can get an opportunity of supervising the waste before loading or even adjusting the form of waste. This will avoid any eventuality of returning. The returning not only involves engaging the transport tankers for one trip during which three normal trips would have been performed, it also means increase of risk. It is, however, also true that operating agency should not accept such material which he cannot handle such as say PCBs, coming suddenly to him unawares. If the return becomes necessary due to discrepancy in the manifest then the operating agency has a room to use his discretion. If the discrepancy is marginal and the material can be accepted by writing a note, he may preferably do so rather than relaying the hazardous waste back all along.

If the operating agency has an acceptable recovered material and a demand for the same, he should make its analysis on Gas Chromatograph (GC) and send the examination report to prospective customer by fax and on his acceptance message the goods be sent. This transport should be done in clean tankers. Dirty tankers should not be pressed for this service, as else unacceptable contamination may take place. The outgoing recovered waste is no more a hazardous waste and hence, manifest system will not be needed. However, it still is a hazardous chemical and whatever obligations under Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 are placed on transport, will have to be studied and followed by the operating agency.

6.9.5 Monitoring

Monitoring and laboratory examination is important in many fields, but more so in the field of hazardous waste management. In monitoring we collect a sample and from its analysis we infer about the universe (i.e. full batch). Monitoring will tell the operating agency about the dividing line between hazardous and non-hazardous waste, about the treatability of the hazardous waste, about incompatibility of different wastes, about the performance efficiency of hazardous waste treatment and disposal facility, about the impact, about the quality of the recovered material, and about the post-closure effects if any. Monitoring gives a final signal if something is going wrong in the facility of operating agency, giving an opportunity of rectification. Monitoring becomes handy in investigation of complaints and during the time of any accidental leakages or spills. The operating agency, therefore, should have an excellent set up of materials and methods.

Monitoring should commence one year before the facility is brought in existence by the operating agency, should continue while the facility is in use, to know the migration kinetics and contemporary concentrations, to take a decision as to whether it is a time to abandon a particular site, and till five year after it is abandoned to see that the "ghost" does not reappear as mere 'cradle to grave' is not sufficient precaution, it should be "cradle to grave to ghost".

In consultation with the SPCBs, the operating agency will have to draw samples of air, water groundwater, leachate waters, soils, ash, solid wastes and aesthetics. The periodicity and station selection be done carefully and the following locations might prove appropriate:-

(a) Air: upwind, downwind, three stations at 120m around the facility, distance depending on stack height and location of any particular sensitive feature. This is for ambient. Samples be selected in stack, vents and ducts.

(b) Surface waters : upstream and downstream in the stream adjoining local nullah, upstream in the rivulet, on both the banks, upper stream and benthal deposits, and add as per sanitary survey.

(c) Groundwater : From wells specially dug one upgradient and at least three on down gradient, and deep enough.

(d) Soil : Surrounding soil at ground level be sampled in a circular grid.

(e) Vegetative cover : Whether mal-effect is occurred and if yes, in what direction.

(f) Biological indicator : by planting sensitive plants in all directions and at different distances and to note periodically as to what is the health status of each plant, providing the operating agency with information as to what further precautions are required to be taken. Figure 6.9 below conceptually shows the operating agency that if the incinerator is at centre and specially selected species of plants/bushes are planted in eight directions at suitable distances, the health effects are as shown by vertical bars when quantified. This is a botanist's job, which can be hired by operating agency.

Among all the above, ground water monitoring is a more serious and complicated matter of which the operating agency has very little experience. The groundwater monitoring is of great significance to such operating agency, who are engaged in land treatment, land application, sanitary landfills, secured landfills, surface impoundment or composting. This monitoring is more significant when the groundwater is popularly used either for agricultural or personal purposes. However, it may be of low or no significance if it is found that the operating agency facility is an engineered structure, does not receive or contain free liquids, is designed and operate to exclude liquid, rains, other run-on or run-off, has both inner and outer layers of containment enclosing the waste, and has an eye on leak detection, i.e. there is no potential for migration of liquid from regulated units to the uppermost aquifer (during the facilities active life and to some extent thereafter). This monitoring is also not significant, if there is no groundwater. This is the first stage of self-examination that the operating agency should keep his findings recorded, supported by expert documents that he should gather by contacting universities.

There are three types of groundwater monitoring, depending on its purpose, viz. (i) detection monitoring, (ii) assessment monitoring and (iii) compliance monitoring. This is shown in a logic chart. The detection monitoring is to determine whether land disposal facility has leaked hazardous waste or constituents into an underlying aquifer in quantities sufficient to cause a significant change in groundwater quality. This can be found out within the first year itself. But if it is detected within say three months, one should not wait for one year, but should immediately begin the assessment monitoring. In detection monitoring, only a few indicator parameters may be analysed to establish, if migration is occurring. The indicator parameters used may include specific conductance, total organic carbon, total organic halogen or any specific waste constituents which the operating agency receives.

Assessment monitoring is a more aggressive programme, if a significant change is discovered in groundwater quality during the detection monitoring. In the place of non-specific, generally, specific chemicals are estimated and vertical-horizontal concentration profiles are attempted. Rate and extent of contaminant migration is studied. This study will lead to design corrective steps to be taken by operating agency.

The success of corrective steps so designed and implemented should be reflected in compliance monitoring. The goal of the compliance monitoring programme is to ensure that leakage of hazardous constituents into the groundwater does not exceed acceptable limits.

The operating agency will know from his experience that these hazardous constituents will be no different than the list of hazardous chemicals given in the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 in its Schedule I, Part II as amended in 1999. The State Boards may not normally announce these limits in the Authorisation. However, if assessment monitoring finds the presence of hazardous chemicals, corresponding standards will be prescribed so that the groundwater remains usable. The corrective action programme by operating agency should include, to remove or treat the constituents specified within an agreed time-frame. The corrective action programme does not terminate, till correction is seen in the groundwater quality.

The operating agency will keep in mind that the groundwater monitoring does not mean a generalised blanket analysis. Specific parameters are required to be selected as a three tier system, viz.(i) indicator parameters, (ii) groundwater quality and (iii) drinking water quality. These can be :

(i) Indicator parameters : to know the pollutant grossly; they are pH, colour, specific conductance, Total Organic Carbon (TOC) and Total Organic Halogen.

(ii) Groundwater quality parameters : to know its suitability for other (non-drinking) purposes like agriculture; they are chloride, iron, manganese, phenols, sodium, sulfates etc.

(iii) Drinking water suitability parameters for its obvious purpose as a source; they are Arsenic, Barium, Cadmium, Chromium, Fluoride (temperature dependent), Lead, Mercury, Nitrate, Selenium, Silver, Endrin, Lindane, Methodxy chlor, Toxaphene, Radio-activity and Coliform bacteria.

For a groundwater quality understanding, there should be sampling points (well) on hydraulically upgradient and a minimum of three on the downgradient, for a small facility of operating agency. However, the number required may increase depending on the complexity of facilities, of geography and of geology. The monitoring well must give a true picture of the groundwater and nothing else. The monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. The casing must be screened or perforated and, if necessary, packed with sand or gravel to enable sample collections at depths were appropriate aquifer flow zones exist. The annular space (the space between the bore hole and the well casing) above the selected sampling depth must be sealed with a suitable material, such as bentonite slurry or grout.

The operating agency shall keep a frequency of sampling as once in three months normally, unless the circumstances compel to do it more often to develop confidence. They should continue even after abandoning the site for a fixed period. All this should be done by the operating agency in constant consultation with the SPCBs. A sequence is suggested by a logic chart (figure 6.10).

It may not be out of place to mention that 175 wells are reportedly monitored monthly by a U.S.A. operating agency, CECOS (M/S.Chemical and Environmental Conservation Systems Inc.) for their secure chemical landfilling at Niagara Falls site, spending a quarter million dollars a year (1986) to check and ensure that groundwater does not become contaminated.

6.9.6 Record Keeping

The operating agency should remember that no job is complete unless paper work is complete. The record keeping and reporting is especially important when dealing with hazardous waste. The operating agency should maintain the minimum record as is required by the hazardous waste rules, but should additionally keep other records like health statistics, insurance, cost analysis and whatever may be required by other departments. The statutory authorities sometimes demand only an annual figure. However, to arrive at, the operating agency has to have a daily record. The minimum requirement can be summarised as follows :

TABLE 6.3 Requirement of information by operating agency

For Form No.	Preparatory figures
1.	Hazardous waste generation - category number - category - origin of manufacturing activity
3.	Description of hazardous waste - physical form - chemical form - quantity (volume and weight) Description of - daily method of storage of hazardous waste - daily method of treatment of hazardous waste Details of transportation - name and address of consignee of package - mode of packing - mode of transportation - date of transportation - quantity transported Details of disposal of hazardous waste (datewise) - date of disposal - Concentration of hazardous material in the final Waste form - Site of disposal (identify the location on the Relevant layout drawing for reference) - method of disposal - name of persons involved in the disposal Data on environmental surveillance - Date of measurement - Groundwater (sampling location, depth of Sampling, results) - Soil (sampling location, depth of sampling, Results) - Air (sampling location, data) - Any other (keep record)
4.	Details of waste disposal operations Description of hazardous waste - Physical form and contents - Chemical form - Total volume of hazardous waste disposed - No. of packages Mode of transportation to the site of disposal

	Site of disposal (attach sketch showing the location of disposal) Brief description of method of disposal Date of disposal Remark (like discrepancy in manifest etc.) Details of environmental surveillance - Date of measurement - Groundwater (sampling location, depth of Sampling, results) - Soil (sampling location, depth of sampling, Results) - Air (sampling location, data) - Any other (keep record)
5.	Accident Reporting - Date and time of the accident - Sequence of events leading to accident - Name of hazardous waste involved in the Accident - Chemical data sheet assessing effect of accident on health and environment - Emergency measures taken - Steps to prevent recurrence of such wastes
7.	Description of imported hazardous waste - Physical form - Chemical form - Total volume & weight (kg) Description of storage, treatment and disposal of hazardous waste - Date - Method of storage - Method of treatment & reuse(give details)

The operating agency should also maintain a record about the inspection visits of the SPCB officials and other inspectors, if any and the instructions given by them on the spot. This should be followed by the compliance letter of the instructions in a reasonable time and acknowledgement obtained. The operating agency shall maintain his own record of treatability studies and characterisation of raw or recovered wastes with various parameters. Record of training too be maintained.

The operating agency should keep it in mind that if he takes care of record daily, the record will take his care in case of an emergency.

6.10 LEGISLATION FOR MANAGEMENT OF HAZARDOUS WASTE AND CATEGORISATION OF HAZARDOUS WASTE

In exercise of the powers conferred under the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has made the Hazardous Waste (Management & Handling) Rules, 1989 and published in the official Gazette No.S.O.594(E), dated 28.7.1989. These Rules define the Hazardous Wastes and provide specific schedule in which wastes are listed for application of the rule. The rules have been further amended in 1999 called Hazardous Waste (Management and Handling) Rules, January 6, 2000. The occupier generating hazardous waste has obligation to take all practical steps to ensure that such wastes are properly handled and disposed off without any adverse effect, which may result from such wastes. The occupier shall also be responsible for proper collection, transportation, treatment, storage and disposal of these wastes, either by himself or through the operator of a facility. The occupier shall submit application to the SPCB for grant of authorisation for handling of hazardous wastes. The SPCB shall not issue an authorisation unless it is satisfied that the operator of a facility or an occupier, as the case may be, possesses appropriate facilities, technical capabilities and equipment to handle hazardous wastes safely.

The State Govt./U.T. Administration, or a person authorised by it, is required to undertake a continuing programme to identify the sites and compile and publish periodically an inventory of disposal sites within the State/UT for the disposal of hazardous wastes. An environmental impact study shall be undertaken before final identification of a site as waste disposal site. Import of hazardous waste from any country to India shall not be permitted for dumping and disposal of such wastes. However, import of such wastes may be allowed for processing or re-use as raw-material, after examining each case on merit by the SPCB or by an officer authorised in this behalf.

The Hazardous Wastes (Management & Handling) Rules apply to the categories of Hazardous Wastes as specified in the Schedule-I to the Rules amended on January 6, 2000 as given at Annexure 6.1

6.11 HANDLING OF HAZARDOUS CHEMICALS

It has been observed that there is always potential risk due to handling and transportation of toxic/ hazardous chemicals and particularly in residential areas. Storage of such chemicals in residential and commercial areas should be closely monitored.

The MoEF have notified the Manufacturer, Storage and Import of Hazardous Chemical Rules, 1989 (as amended on January 20, 2000) and according to these rules, activities relating to handling and transportation of hazardous chemicals should be regulated. However, this subject is not under the purview of local bodies but, they can provide assistance to the concerned agencies whenever needed.

6.12 INDUSTRIAL LOCATION

There are certain types of industries though they are small sized/tiny but, cause considerable pollution when they are located in residential areas. Such industries quite often do not seek s 'Consents' from SPCBs and even not 'licensed' by the local authorities. Therefore, SPCBs and Municipal authorities should review and interact with each other to ensure that industries do not come up in non-conforming areas. From solid waste generation point of view, small industries dispose variety of solid waste like, packaging materials, oil sludges, scraps, paints, metallic/non-metallic containers, metallic sludges, etc. Based on pollution potential, category of industries which may be examined and restricted for their siting in residential areas may be referred in the Annexure 6.2.

Municipal authorities while providing services in residential and commercial areas when find that there are industries which discharge solid waste, should bring out information to the knowledge of SPCBs so that necessary actions are taken. In commercial areas, service units like flour mills, automobile service stations should be properly served notices by the concerned administration to the effect that such units should dispose their solid waste as per norms laid by Pollution Control Boards/ municipal authorities.

6.13 MANAGEMENT OF INDUSTRIAL SOLID WASTES-CO-ORDINATION (SPCBs & LOCAL BODIES)

Urban local bodies are constantly in the field and they are well aware of the local situation. They also know sources of waste generation and areas under their control. In order to organise proper collection, transportation and disposal of industrial solid waste, there is need to set up co-ordination between SPCBs, local bodies and industrial departments. Following guidelines are suggested to follow :

i) Urban local bodies should identify the areas from where industrial solid waste is generated.

ii) Inventorisation of industries could be attempted through SPCBs or industries department for characterisation of wastes.

iii) SPCBs may take necessary actions for issuance of consents/Authorisations to the industries under relevant Acts and Rules.

iv) Urban local bodies may undertake collection, transportation and disposal of solid waste on cost recovery basis as per existing rules and may identify suitable sites for final treatment and disposal of industrial solid waste as per existing rules and regulations.

ANNEXURE 6.1

Categories of Industries to be restricted for their operation in non-conforming areas. (only an indicative list)

S.No	Category of Industry	S.No.	Category of Industry
1.	Tanneries (Tanning units)	2	Lubricating oils, greases or petroleum based products
3	Battery manufacturing units	4	Synthetic detergent and soap
5	Foundries	6	Industrial or inorganic gases
7	Electroplating	8	Glue and gelatine
9	Small pulp and paper units	10	Vegetable oils including solvent extracted oils, hydro-generated oils
11	Tyre and Tubes vulcanizing units	12	Industry or process involving metal treatment or process such as pickling, surface coating, paint baking, paint stripping, heat treatment, phosphating or finishing etc.
13	Rubber and Rubber Products (inclu-ding synthetic rubber)	14	Industry or process involving electroplating operations.
15	Plastic and Plastic Products	16	Slaughter houses and meat processing units
17	Glass and fibre glass production and processing	18	Steel and steel products or any of the operations or processes such as heat treatment, acid pickling, rolling or galvanishing etc.
19	Chemicals	20	Fire crackers

21	Dying and Printing	22	Ceramic/refractories
23	Denting and Painting	24	Automobile servicing and repairs stations
25	Dye & dye intermediates	26	Handloom Weaving
27	Pharmaceuticals	28	Gold and silver smithy
29	Iron and Steel (Involving processing from ore/scrap/Integrated steel Plants)	30	Tobacco products including ciga-rettes and tobacco processing
31	Zinc Smelters	32	Fish processing
33	Industrial carbon including electrodes and graphite blocks, activated carbon, carbon black etc.	34	Flour mills (excluding Domestic Atta Chakki)
35	Paints and Varnishes (excluding blending/ mixing)	36	Lead processing and battery reconditioning & Manufacturing including lead smelting
37	Pigments and intermediates	38	Non-alcoholic beverages (soft drinks)
39	Petroleum products involving storage, transfer or processing	40	Food including fruits and vege-table processing.
41	Automobile servicing and repairs stations.	42	Pulping and fermenting of coffee beans
43	Leather footwear & Leather products	44	Fragrances and industrial perfumes
45	Food additives, nutrients and flavours	46	Wires drawing (cold process and bailing straps

47	Pesticides/ Insecticides/ Fungicides/ Herbicides/Agrochemical formulation	48	Printing press
49	Asbestos and asbestos products	50	Storage batteries (integrated with manufacture of oxides of lead and lead antimony alloy)
51	Pharmaceuticals	52	Re-rolling mills
53	Metal castings	54	Reclaimed oils
55	Alkalies (such as sods ash, precipitated calcium carbonate, potassium hydroxide etc.)	56	Varnishes
57	Meat processing units	58	Solvent extraction of oil units
59	Resins	60	Bleaching
61	Slaughtering of animals, rendering of bones and processing	62	Textile chemicals
63	Nickel and cadmium batteries		

CHAPTER 7
BIO-MEDICAL WASTE

7.1 INTRODUCTION

Medical care is vital for our life, health and well being. But the waste generated from medical activities can be hazardous, toxic and even lethal because of their high potential for diseases transmission. The hazardous and toxic parts of waste from health care establishments comprising infectious, bio-medical and radio-active material as well as sharps (hypodermic needles, knives, scalpels etc.) constitute a grave risk, if these are not properly treated/disposed or is allowed to get mixed with other municipal waste. **Its propensity to encourage growth of various pathogen and vectors and its ability to contaminate other non-hazardous/non-toxic municipal waste jeopardises the efforts undertaken for overall municipal waste management.** The rag pickers and waste workers are often worst affected, because unknowingly or unwittingly, they rummage through all kinds of poisonous material while trying to salvage items which they can sell for reuse. At the same time, this kind of illegal and unethical reuse can be extremely dangerous and even fatal. Diseases like cholera, plague, tuberculosis, hepatitis (especially HBV), AIDS (HIV), diphtheria etc. in either epidemic or even endemic form, pose grave public health risks. Unfortunately, in the absence of reliable and extensive data, it is difficult to quantify the dimension of the problem or even the extent and variety of the risk involved.

With a judicious planning and management, however, the risk can be considerably reduced. Studies have shown that about three fourth of the total waste generated in health care establishments is non-hazardous and non-toxic. Some estimates put the infectious waste at 15% and other hazardous waste at 5%. Therefore with a rigorous regime of segregation at source, the problem can be reduced proportionately. Similarly, with better planning and management, not only the waste generation is reduced, but overall expenditure on waste management can be controlled. Institutional/Organisational set up, training and motivation are given great importance these days. Proper training of health care establishment personnel at all levels coupled with sustained motivation can improve the situation considerably.

The rules framed by the Ministry of Environment and Forests (MoEF), Govt. of India, known as **'Bio-medical Waste (Management and Handling) Rules, 1998,'** notified on 20th July 1998, provides uniform guidelines and code of practice for the whole nation. It is clearly mentioned in this rule that the **'occupier'** (a person who has control over the concerned institution / premises) of an institution generating bio-medical waste (e.g., hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank etc.) **shall be responsible for taking necessary steps to ensure that such waste is handled without any adverse effect to human health and the environment.**

Definition : 'Bio-medical waste' means any solid and/or liquid waste including its container and any intermediate product, which is generated during the diagnosis, treatment or immunisation of human beings or animals or in research pertaining thereto or in the production or testing thereof.

The physico-chemical and biological nature of these components, their toxicity and potential hazard are different, necessitating different methods / options for their treatment / disposal. In Schedule I of the Bio-medical Waste (Management and Handling) Rules, 1998 (Annexure II), therefore, the waste originating from different kinds of such establishments, has been categorised into 10 different categories (as mentioned in the box below) and their treatment and disposal options have been indicated.

Components of Bio-medical waste

(i) human anatomical waste (tissues, organs, body parts etc.),

(ii) animal waste (as above, generated during research/experimentation, from veterinary hospitals etc.),

(iii) microbiology and biotechnology waste, such as, laboratory cultures, micro-organisms, human and animal cell cultures, toxins etc.,

(iv) waste sharps, such as, hypodermic needles, syringes, scalpels, broken glass etc.,

(v) discarded medicines and cyto-toxic drugs

(vi) soiled waste, such as dressing, bandages, plaster casts, material contaminated with blood etc.,

(vii) solid waste (disposable items like tubes, catheters etc. excluding sharps),

(viii) liquid waste generated from any of the infected areas,

(ix) incineration ash,

(x) chemical waste.

Health hazards associated with poor management of Bio-medical waste

(i) Injury from sharps to staff and waste handlers associated with the health care establishment.

(ii) Hospital Acquired Infection(HAI)(Nosocomial) of patients due to spread of infection.

(iii) Risk of infection outside the hospital for waste handlers/scavengers and eventually general public.

(iv) Occupational risk associated with hazardous chemicals, drugs etc.

(v) Unauthorised repackaging and sale of disposable items and unused / date expired drugs.

The environmental hazards are mentioned at 7.4.2.

7.1.1 Linkage of Bio-medical Waste Management with Municipal Waste Management

At present, the role of the civic body with respect to the management of bio-medical waste is not clearly defined, leading to confusion and laxity from either side.

- Since majority of the health care establishments are located within the municipal area, their waste management naturally has a close linkage with the municipal system. At the same time, the civic authority is responsible for public health in the whole of the municipal area. Therefore, the health care establishments must have a clear understanding with the municipality regarding sharing of responsibilities associated with this issue.
- Studies have shown that about three fourth of the total hospital waste is not hazardous / infected (provided strict segregation is practised) and can even be taken care of by the municipal waste management system, e.g., waste generated at the hospital kitchen or garden, the office or packaging material from the store etc.
- Such practices of strict and careful segregation would reduce the load and the cost of management of the actually hazardous and infected bio-medical waste (collection, transportation, treatment and disposal).

- Since, it would not be possible for each and every health care establishment to have its own full fledged treatment and disposal system for bio-medical waste, there would be need for common treatment and disposal facilities under the ownership/supervision/guidance of the civic authority (discussed in para 7.9).

From the above mentioned issues, it is clear that the success of the bio-medical waste management program depends on proper in-house management (within the health care establishment) and co-ordination and co-operation amongst the various establishments themselves as well as with the civic authority. Hence this chapter discusses both these aspects.

7.2 ASSESSMENT OF CURRENT SITUATION

An assessment of the situation obtaining within the individual health care establishments as well as the town/city as a whole is necessary before making any attempts for improvement. Essentially this involves three steps :

- survey of waste generation
- documentation of prevailing practices
- allocation of responsibilities

7.2.1 Waste Generation

Qualitative as well as quantitative survey of the waste generated is the goal of this step. This needs to be broadly carried out for :

(i) Health care establishments - as units and

(ii) The whole town / city

7.2.1.1 Health Care Establishments

Each establishment has to chalk out a programme for qualitative as well as quantitative survey of the waste generated depending on the medical activities and procedures followed by it. In order to asses the current situation, the following have to be included (as applicable) in the survey as per the time frame indicated :

Table 7.1 : Area-wise Frequency of Waste Survey

Area/Department/Unit	Frequency of data collection
Wards (each one of them)	Each shift
Operation theatre (OT)(- do -)	Each operation / surgical procedure
Out Patients Department (OPD)	Each shift
Intensive Care Unit (ICU)	Each shift
Emergency unit	Each shift
Dialysis unit	Each procedure
Radiation unit	Each procedure
Laboratories (pathological, biochemical)	Each shift
Pharmacy / Chemist's dispensation unit	Once a day
Kitchen	Twice, after every meal
Administrative unit and central store	Once a day
Surrounding premises and garden	Once a day

The concerned medical establishment should constitute a team of its experts, concerned personnel and workers (doctors, chemists, laboratory technicians, hospital engineers, nurses, cleaning supervisors/inspectors, cleaning staff etc.). If such expertise is not available, it may take the help of external experts in the field who can help them carry out the survey work. A third alternative is possible if expert agencies are available who carry out the whole work on contract as a package.

In either case, the medical establishment has to earmark a suitable place where the qualitative and quantitative tests can be carried out. This place should be an enclosed space. Depending upon the requirement, it can be a large room or a hall or at least a covered shade with proper fencing. Unauthorised entry to this space should be strictly restricted. It should be well lighted. The place should be washed and disinfected daily and preferably dry and clean.

The waste generated by all the departments has to be collected according to the prevailing practices of collection but due care has to be taken to see that no portion of the total waste generated is missed out from this survey. The waste so collected (except the liquid waste and incineration ash) has to be sorted out into the different categories according to the Schedule I of the Biomedical Waste (Management and Handling) Rules, 1998 (as applicable).

If an incinerator is operating within the hospital campus, then the **incinerator ash** produced every day has to be weighed. This can be done once a day. At the same time the total waste incinerated every day has also to be recorded.

The **liquid waste** may be divided into two components : (a) liquid reagents/chemicals discarded and (b) the cleaning and washing water channelled into the drain. The first component can be easily measured by a measuring cylinder or other suitable measuring device before discarding each time and keeping suitable records. The second component can be derived from the total water used in the hospital or by using appropriate flow metres.

Table 7.2 : Category-wise Survey of Waste Generation

Item (as per schedule)	Wt. (kg.) Shift I	Wt.(kg.) Shift II	Wt.(kg) Shift III	Total Wt.(kg.)
Human anatomical waste				
Animal waste				
Microbiology & biotechnology waste				
Waste sharps				
Medicines and cyto-toxic drugs				
Soiled waste				
Solid waste				
Chemical waste				
Incineration ash				
Liquid waste (litres)				

The survey needs to be carried out at least for 3 days a week in continuation followed by similar exercise for 4 weeks (preferably alternate weeks for better reproducibility of the data). The result is then compiled for both quantitative as well as qualitative data.

7.2.1.2 Whole Town/City

A simultaneous survey of the situation in the town or city concerned is essential for a proper planning. The first issue to be resolved is - who should get the survey done

- local body ?

- health authorities ?
- Indian Medicines Association (IMA)/association of health care establishments ?

A suitable consultant should be engaged for carrying out the job. The concerned authorities must prepare a Terms of Reference (TOR) for this job in accordance with the need of the town/city. In case this is not possible, then a calculation may be made based on the number of beds and average waste generated per bed. Since there is no prevailing practice of keeping hospital waste separate and of taking the whole of it to specific locations, it would be very difficult to get any reliable figures from the municipal collection system. Hence a separate exercise needs to be carried out.

7.2.2 Current Practices

The current practices in relation to waste management in the particular health care establishment need to be recorded with respect to the following activities for each unit (i.e., wards, operation theatres, laboratories etc.) :

- Storage of waste at the point of generation.
- Whether one container is used for all waste or different containers are used for different types of waste ?
- How frequently the waste material is removed and to where ?
- Is there any intermediate storage of the waste before it is moved in bulk outside the hospital campus ?
- Who removes the waste material from the points of generation ?
- Whether any measures are taken to deter further unauthorised reuse of the discarded items, such as cutting/ mutilating needles, plastic tubes, gloves etc. ?
- Is there an incineration plant in the hospital ? If yes, what are the materials incinerated and what happens to the ash/ clinkers?
- What happens to the waste once it is removed from the health care establishment - can it be tracked ?
- Is there any strategy/plan and administrative support for tackling this issue?

7.2.3 Allocation of Responsibilities

The administrative head of the health care establishment should carry out an exercise of documenting the current allocation of responsibilities with relation to waste management within its premises. In large establishments, specialised services of consultants/experts should be sought. Each departmental head should be involved in the exercise. Organisational chart indicating specific accountability of staff at each level in each department needs to be prepared.

7.3 BASIC ISSUES

Health care waste is a heterogeneous mixture, which is very difficult to manage as such. But the problem can be simplified and its dimension reduced considerably if a proper management system is planned. Therefore it is important to take a brief look at the management issues.

7.3.1 Management Issues of Bio-medical Waste Management

The management principles are based on the following aspects :

- Reduction/control of waste (by controlling inventory, wastage of consumable items, reagents, breakage etc.).
- Segregation of the different types of wastes into different categories according to their treatment/disposal options given in Schedule I of the Rules mentioned above.
- Segregated collection and transportation to final treatment/disposal facility so that they do not get mixed.
- Proper treatment and final disposal as indicated in the rules.
- Safety of handling, full care/protection against operational hazard for personnel at each level.
- Proper organisation and management.

7.3.2 Current Issues in Management of Health Care Waste

There are two main issues at present :

- the recent legislation by the Govt. of India and
- implementation of the same at individual health care establishments level as well as whole town / city level.

The recent legislation has fulfilled a long standing necessity. Now this sector has got clear cut guidelines which should be able to initiate a uniform standard of practice through out the country.

It would be necessary to implement proper bio-medical waste management system for each and every hospital, nursing home, pathological laboratory etc. Comprehensive management system for each and every health care establishment has to be planned for optimal techno-economic viability. **At the same time the final disposal for the whole town must not be lost sight of. Since there are a large number of small and medium health care establishments, common treatment and disposal facilities are essential.**

7.4. LEGAL ASPECTS AND ENVIRONMENTAL CONCERN

Indiscriminate disposal of infected and hazardous waste from hospitals, nursing homes and pathological laboratories has led to significant degradation of the environment, leading to spread of diseases and putting the people to great risk from certain highly contagious and transmission prone disease vectors. This has given rise to considerable environmental concern.

The first standard on the subject to be brought out in India was by the Bureau of Indian Standards (BIS), IS 12625 : 1989, entitled 'Solid Wastes-Hospitals-Guidelines for Management' (Annexure 7.1) but it was unable to bring any improvement in the situation. In this scenario, the notification of the **'Bio-medical waste (Management & Handling) Rules, 1998'** assumes great significance.

7.4.1. Bio-medical Waste (Management and Handling) Rules, 1998

The Central Govt. has notified these rules on 20th July, 1998 in exercise of section 6, 8 and 25 of the Environment (Protection) Act, 1986. Prior to that, the draft rules were gazetted on 16th October, 1997 and Public suggestion/comments were invited within 60 days. These suggestion were considered before finalising the rules. The text of the rules(English version) is annexed (Annexure-7.2).

Scope and application of the Rules

These rules apply to all those who generate, collect, receive, store, transport, treat, dispose or handle bio-medical waste in any form.

According to these rules, it shall be the duty of every occupier of an institution generating bio-medical waste, which includes hospitals, nursing homes, clinics, dispensaries, veterinary institution, animal houses, pathology laboratories, blood banks etc., to take all steps to ensure that such wastes are handled without any adverse effect to human health and the environment. They have to either set up their own facility within the time frame (schedule VI) or ensure requisite treatment at a common waste treatment facility or any other waste treatment facility.

Every occupier of an institution, which is generating, collecting, receiving, storing, transporting, treating, disposing and/or handling bio-medical waste in any other manner, except such occupier of clinics, dispensaries, pathological laboratories, blood banks etc., which provide treatment/service to less than 1000 (one thousand) patients per month shall make an application in prescribed form to the prescribed authority for grant of authorisation to carry on the work. Whenever an accident occurs concerning bio-medical waste, it has to be reported to this authority.

Each State and Union Territory (UT) Government shall be required to establish a prescribed authority for this purpose. The respective governments would also constitute advisory committees to advise the Govts with respect to implementation of these rules. The occupier or operator can also appeal against any order of the authority if they feel aggrieved to such other authority as the Govt. of the State/UT may think fit to constitute. Prescribed Authorities, so far established by various State Governments are listed at Annexure 7.3 and the time limit as per schedule VI of the 'Bio-Medical(Management & Handling) Rules,1998.

7.4.2 Environmental Concern

The following are the main environmental concerns with respect to improper disposal of bio-medical waste management:

- Spread of infection and disease through vectors (fly, mosquito, insects etc.) which affect the in -house as well as surrounding population.
- Spread of infection through contact/injury among medical/non-medical personnel and sweepers/rag pickers, especially from the sharps (needles, blades etc.).
- Spread of infection through unauthorised recycling of disposable items such as hypodermic needles, tubes, blades, bottles etc.
- Reaction due to use of discarded medicines.

- Toxic emissions from defective/inefficient incinerators.
- Indiscriminate disposal of incinerator ash / residues.

7.5. WASTE IDENTIFICATION AND WASTE CONTROL PROGRAM FOR THE HEALTH CARE ESTABLISHMENTS

In fact waste identification is an important tool of waste control programme. The necessity of segregation has already been mentioned. The use of colour coding and labelling of hazardous waste containers provides great assistance in waste separation. Without opening a container one can easily know about the contents. Therefore, in addition to segregation, separate transportation and storage is also facilitated.

7.5.1 Identification of Various Components of the Waste Generated

The Bio-medical waste (Management and Handling) Rules, 1998 says that such waste shall be segregated into containers/bags at the point of generation in accordance with Schedule II of the rules prior to its storage, transportation, treatment and disposal. This would help in easy identification of the various components of health care waste. **All containers bearing hazardous material must be adequately labelled according to Schedule IV of the Rules** (Annexure 7.2).

7.5.2. An Exercise in Waste Control Programme

For larger health care establishments such as hospitals, a comprehensive exercise needs to be carried out for evolving its own waste management plan/programme, consisting of the following steps:

1. Documenting the medical/bio-medical practice/procedures carried out by the particular health care establishment by enlisting categories of waste generated as per schedule I of the rules.
2. Assessing current practices and responsibilities (as mentioned earlier).
3. Assessing current costs for hazardous waste management.
4. Developing an effective bio-medical waste management policy/plan according to the Rules and
5. Implementation of the plan.

It is important to identify the current costs associated with waste management. Purchasing and inventory practices, for example, must be closely examined to identify the costs related to the disposables, recyclables etc. All associated materials (e.g. gloves, boots, brushes, disinfectants etc.), cost of fuel (for incinerator, vehicles), electricity etc. as well as man hours should be accounted for.

Based on these results, a comprehensive policy has to be framed in consonance with the govt. rules so that compliance is achieved. An official statement incorporating all practices from the segregated storage through transportation, treatment and final disposal should be prepared and widely circulated after due approval.

7.6 WASTE STORAGE

Storage of waste is necessary at two points :

(i) at the point of generation and

(ii) common storage for the total waste inside a health care organisation.

For smaller units, however, the common storage area may not be possible. Systematic segregated storage is the most important step in the waste control programme of the health care establishment. For ease of identification and handling it is necessary to use colour coding, i.e., use of specific coloured container with liner / sealed container (for sharps) for particular wastes. It must be remembered that according to the Rules, untreated waste should not be stored beyond a period of 48 hours.

7.6.1 Recommended Labelling and Colour Coding

These have to be in accordance with Schedule II of the notified rules (Annexure 7.2). A simple and clear notice, describing which waste should go to which container and how frequently it has to be routinely removed and to where, is to be pasted on the wall or at a conspicuous place nearest to the container. The notice should be in English, Hindi and the predominant local language. Preferably, it should have drawings correlating the container in appropriate colour with the kind of waste it should contain.

7.6.2 Segregated Storage in Separate Containers (at the Point of Generation)

Each category of waste (according to treatment options mentioned in Schedule I of the rules) has to be kept segregated in a proper container or bag as the case may be. Such container / bag should have the following property :

- It must be sturdy enough to contain the designed maximum volume and weight of the waste without any damage.
- It should be without any puncture/leakage.
- The container should have a cover, preferably operated by foot. If plastic bags are to be used, they have to be securely fitted within a container in such a manner that they stay in place during opening and closing of the lid and can also be removed without difficulty.
- The sharps must be stored in puncture proof sharps containers. But before putting them in the containers, they must be mutilated by a needle cutter, placed in the department/ward itself.

The bags/containers should not be filled more than 3/4th capacity. Attempts should be made to designate fixed places for each container so that it becomes a part of regular scenario and practice for the concerned medical as well as nursing staff. The specification for the containers is mentioned in chapter 4 of this manual.

7.6.3 Certification

When a bag or container is sealed, appropriate label (s) clearly indicating the following information (as per Schedule IV of the Rules) has to be attached. A water-proof marker pen should be used for writing.

They should be labelled with the 'Biohazard' or 'cyto-toxic' symbol as the case may be according to Schedule III of the rules (Annexure 7.2).

- The containers should bear the name of the department/laboratory from where the waste has been generated so that in case of a problem or accident, the nature of the waste can be traced back quickly and correctly for proper remediation and if necessary, the responsibility can be fixed.
- The containers should also be labelled with the date, name and signature of the person responsible. This would generate greater accountability.
- The label should contain the name, address, phone/fax nos. of the sender as well as the receiver.

- It should also contain name, address and phone/fax nos. of the person who is to be contacted in case of an emergency.

7.6.4 Common/Intermediate Storage Area

Collection room(s)/intermediate storage area where the waste packets/bags are collected before they are finally taken/transported to the treatment/disposal site are necessary for large hospitals having a number of departments, laboratories, OTs, wards etc. This is all the more important when the waste is to be taken outside the premises. Two rooms - one for the general and the other for the hazardous waste are preferable (details at 7.14.1, 5th point). In case of shortage of rooms, the general waste (non-hazardous) can be directly stored outside in dumper containers with lids of suitable size.

Arrangement for separate receptacles in the storage area with prominent display of colour code on the wall nearest to the receptacles has to be made. When waste carrying carts/containers arrive at this area, they have to be systematically put in the relevant receptacle/designated area.

7.6.5 Parking Lot for Collection Vehicles

A shed with fencing should be provided for the carts, trolleys, covered vehicles etc. used for collecting or moving the waste material. Care has to be taken to provide separate sheds for the hazardous and non-hazardous waste so that there is no chance of cross contamination. Both the sheds should have a wash area provided with adequate water jets, drains, raised platform, protection walls to contain splash of water and proper drainage system.

7.7 HANDLING AND TRANSPORTATION

This activity has three components: collection of different kinds of waste (from waste storage bags/containers) inside the hospital, transportation and intermediate storage of segregated waste inside the premises and transportation of the waste outside the premises (to the treatment/disposal facility).

7.7.1 Collection of Waste Inside the Hospital/Health Care Establishment

The collection containers for bio-medical waste have to be sturdy, leak proof, of adequate size and wheeled. Two wheeled bins of 120-330 litre capacity and four wheeled bins of 500-1000 litre capacity (IS 12402, Part I, 1988) may be used. The 4 wheeled containers have two fixed wheels and two castors and they are fitted with wheel locking devices to prevent unwanted rolling. There should be no sharp edges or corners, especially in metallic bins. Specifications of bins are mentioned in chapter 4 of this manual. For convenience as well as for avoiding any confusion, the colour code applicable for the bags / containers should also be used for the bins.

Collection timings and duty chart should be put in a prominent place with copies given to the concerned waste collectors and supervisors. For general waste from the office, kitchen, garden etc., normal wheel-barrows may be used.

7.7.2 Transportation of Segregated Waste Inside the Premises

All attempts should be made to provide separate service corridors for taking waste matter from the storage area to the collection room. Preferably these corridors should not cross the paths used by patients and visitors. The waste has to be taken to the common storage area first, from where it is to be taken to the treatment/disposal facility, either within or outside the premises as the case may be.

As already mentioned under 7.6.4, the wheel-barrows containing general waste may be sent to a dumper container or further segregated as described under section 7.8.7 (later).

7.7.3 Collection and Transportation of Waste for Small Units

Smaller units, such as, nursing homes, pathological laboratories etc. do not have many departments/divisions and the generation of waste is small and normally they do not have treatment facility for the bio-medical waste.

In their case, intermediate storage area is not required. They should install a needle cutter and a small device for cutting plastic tubing, gloves etc. In case, highly infectious bio-medical waste is expected to be generated, they may consider to install a separate steam autoclave of suitable size exclusively for this purpose. Adequate precaution must be taken to ward off any occupational hazard or environmental problem. This particular autoclave should never be used for sterilising medical supplies or surgical equipment.

Such establishments require provision for segregated storage (according to the rules) which can be packed in sealed containers/sturdy bags and handed over to the agency carrying them to the common treatment/disposal facility.

7.7.4 Transportation of Waste Outside

In case of off-site treatment, the waste has to be transported to the treatment/disposal facility site in a safe manner. The vehicle, which may be a specially designed van, should have the following specifications :

- It should be covered and secured against accidental opening of door, leakage/spillage etc.
- The interior of the container should be lined with smooth finish of aluminium or stainless steel, without sharp edges/corners or dead spaces, which can be conveniently washed and disinfected.
- There should be adequate arrangement for drainage and collection of any run off/leachate, which may accidentally come out of the waste bags/containers. The floor should have suitable gradient, flow trap and collection container.
- The size of the van would depend on the waste to be carried per trip.
- In case, the waste quantity per trip is small, covered container of 1-2 cu. m., mounted on 3 wheeled chassis and fitted with a tipping arrangement can be used.

7.8 WASTE TREATMENT AND DISPOSAL : THE RULES AND THE AVAILABLE OPTIONS

Different methods have been developed for rendering bio-medical waste environmentally innocuous and aesthetically acceptable but all of them are not suitable for our condition. The 'Bio-Medical Waste (Management & Handling) Rules, 1998' has elaborately mentioned the recommended treatment and disposal options according to the 10 different categories of waste generated in health care establishments in Schedule I of the rules (Annexure 7.2). Standards for the treatment technologies are given in Schedule V of the Rules, which must be complied with. A comparison of the advantages and limitations of the different technologies for treatment of bio-medical waste is given at Annexure 7.4.

A review of the above schedule would show that there is no single technology, which can take care of all categories of bio-medical waste. A judicious package has to be evolved for this purpose. For example, small and medium hospitals can opt for local (in house) disinfection, mutilation / shredding and dedicated autoclaving plus off-site incineration at a common treatment / disposal facility followed by disposal in sanitary and secured landfills.

7.8.1 Incineration

This is a high temperature thermal process employing combustion of the waste under controlled condition for converting them into inert material and gases. Incinerators can be oil fired or electrically powered or a combination thereof. Broadly, three types of incinerators are used for hospital waste : multiple hearth type, rotary kiln and controlled air types. All the types can have primary and secondary combustion chambers to ensure optimal combustion. These are refractory lined.

In the multiple hearth incinerator, solid phase combustion takes place in the primary chamber whereas the secondary chamber is for gas phase combustion. These are referred to as excess air incinerators because excess air is present in both the chambers. The rotary kiln is a cylindrical refractory lined shell that is mounted at a slight tilt to facilitate mixing and movement of the waste inside. It has provision of air circulation. The kiln acts as the primary solid phase chamber, which is followed by the secondary chamber for the gaseous combustion. In the third type, the first chamber is operated at low air levels followed by an excess air chamber. Due to low oxygen levels in the primary chamber, there is better control of particulate matter in the flue gas.

In a nutshell, the primary chamber has pyrolytic conditions with a temperature range of about 800 (+/-) 50 deg. C. The secondary chamber operates under excess air conditions at about 1050 (+/-)50 deg. C (Schedule V of the Rules). The volatiles are liberated in the first chamber whereas they are destroyed in the second one. Some models are fitted with Eductor mechanism, which maintains the system under negative pressure and helps control the flue gases more effectively. The chimney height should be minimum 30 meters above ground level. Installation of incinerators in congested area is not desirable.

In the Bio-medical Waste (Management and Handling) Rules, Incineration has been recommended for human anatomical waste, animal waste, cyto-toxic drugs, discarded medicines and soiled waste.

7.8.2 Autoclave Treatment

This is a process of steam sterilisation under pressure. It is a low heat process in which steam is brought into direct contact with the waste material for duration sufficient to disinfect the material. These are also of three types : Gravity type, Pre-vacuum type and Retort type.

In the first type (Gravity type), air is evacuated with the help of gravity alone. The system operates with temperature of 121 deg. C. and steam pressure of 15 psi. for 60-90 minutes. Vacuum pumps are used to evacuate air from the Pre-vacuum autoclave system so that the time cycle is reduced to 30-60 minutes. It operates at about 132 deg. C. Retort type autoclaves are designed to handle much larger volumes and operate at much higher steam temperature and pressure.

Autoclave treatment has been recommended for microbiology and biotechnology waste, waste sharps, soiled and solid wastes (as mentioned in the table above). This technology renders certain categories (mentioned in the rules) of bio-medical waste innocuous and unrecognisable so that the treated residue can be landfilled. Sanjay Gandhi Memorial Hospital in Delhi has installed a Pre-vacuum Autoclave.

7.8.3 Hydroclave Treatment

Hydroclave is an innovative equipment for steam sterilisation process (like autoclave). It is a double walled container, in which the steam is injected into the outer jacket to heat the inner chamber containing the waste. Moisture contained in the waste evaporates as steam and builds up the requisite steam pressure (35-36 psi). Sturdy paddles slowly rotated by a strong shaft inside the chamber tumble the waste continuously against the hot wall thus mixing as well as fragmenting the same. In the absence of enough moisture, additional steam is injected. The system operates at 132 deg.C. and 36 psi steam pressure for sterilisation time of 20 minutes. The total time for a cycle is about 50 minutes, which includes start-up, heat-up, sterilisation, venting and depressurisation and dehydration. The treated material can further be shredded before disposal. The expected volume and weight reductions are upto 85% and 70% respectively.

The hydroclave can treat the same waste as the autoclave plus the waste sharps. The sharps are also fragmented. This technology has certain benefits, such as, absence of harmful air emissions, absence of liquid discharges, non-requirement of chemicals, reduced volume and weight of waste etc.

Tata Memorial Hospital in Mumbai has installed the first hydroclave in India in September 1999.

7.8.4 Microwave Treatment

This again is a wet thermal disinfection technology but unlike other thermal treatment systems, which heat the waste externally, microwave heats the targeted material from inside out, providing a high level of disinfection.

The input material is first put through a shredder. The shredded material is pushed to a treatment chamber where it is moistened with high temperature steam. The material is then carried by a screw conveyor beneath a series (normally 4-6 nos.) of conventional microwave generators, which heat the material to 95-100 deg. C. and uniformly disinfect the material during a minimum residence time of 30 minutes and total cycle is of 50 minutes. A second shredder fragments the material further into unrecognisable particles before it is automatically discharged into a conventional / general waste container. This treated material can be landfilled provided adequate care is taken to complete the microwave treatment. In the modern versions, the process control is computerised for smooth and effective control.

Microwave technology has certain benefits, such as, absence of harmful air emissions (when adequate provision of containment and filters is made), absence of liquid discharges, non requirement of chemicals, reduced volume of waste (due to shredding and moisture loss) and operator safety (due to automatic hoisting arrangement for the waste bins into the hopper so that manual contact with the waste bags is not necessary). However, the investment cost is high at present.

According to the rules, category nos, 3 (microbiology and biotechnology waste), 4 (waste sharps), 6 (soiled waste) and 7 (solid waste) are permitted to be microwaved.

7.8.5 Chemical Disinfecting

This treatment is recommended for waste sharps, solid and liquid wastes as well as chemical wastes. Chemical treatment involves use of at least 1% hypochlorite solution with a minimum contact period of 30 minutes or other equivalent chemical reagents such as phenolic compounds, iodine, hexachlorophene, iodine-alcohol or formaldehyde-alcohol combination etc. Pre-shredding of the waste is desirable for better contact with the waste material.

In the USA, chemical treatment facility is also available in mobile vans. In one version, the waste is shredded, passed through 10% hypochlorite solution (dixichlor) followed by a finer shredding and drying. The treated material is landfilled.

7.8.6 Sanitary and Secured Landfilling

Sanitary and secured landfilling is necessary under the following circumstances :

- Deep burial of human anatomical waste when the facility of proper incineration is not available (for towns having less than 5 lakh population and rural areas, according to Schedule I of the MoEF rules - Secured landfill). A schematic of deep burial is shown as per Annexure 7.5
- Animal waste (under similar conditions as mentioned above) - Secured landfill.
- Disposal of autoclaved/hydroclaved/microwaved waste (unrecognisable) - Sanitary landfill.
- Disposal of incineration ash - Sanitary landfill.
- Disposal of bio-medical waste till such time when proper treatment and disposal facility is in place - Secured landfill.
- Disposal of sharps - Secured landfill. This can also be done within a hospital premises as mentioned below.

In case disposal facility for sharps is not readily available in a town, health care establishments, especially hospitals having suitable land, can construct a concrete lined pit of about 1m length, breadth and depth and cover the same with a heavy concrete slab having a 1 - 1.5 m high steel pipe of about 50 mm diameter. Disinfected sharps can be put through this pipe. When the pit is full, the pipe should be sawed off and the hole sealed with cement concrete. This site should not be water logged or near a borewell.

7.8.7 General Waste

The waste material generated from the office, kitchen, garden, store, chemicals counter etc., which are non-hazardous and non-toxic, may be taken care of as follows :

- Composting of green waste - to be carried to a municipal facility or a private facility, if available. If suitable land is available, a hospital may consider composting its green waste within the campus itself taking all precautions regarding health and hygiene and safety to patients.
- Recycling of packaging material (caution - medical supplies such as unused or scantily used disposable items or those of uncertain history should never be allowed to be recycled).

Certificate indicating origin and of non-contamination, issued by the concerned medical authorities of the health care establishment before these wastes are handed over to the municipality / private operator is essential from the point of safety.

7.9 COMMON TREATMENT/DISPOSAL FACILITY

Common treatment facilities are necessary because it is not feasible for smaller health care establishments to set up a complete treatment and disposal system due to lack of space and trained manpower, minimum scale of operation and scale of economy. Even large establishments located in congested or densely populated areas can not have such units due to environmental constraints. According to the rules, different kinds of treatment are required for different components of health care waste and the post-treatment residues have to be safely disposed. Hence, it is desirable that every town/city should have at least one common treatment facility, which may be used by all the units who can not have their own facility. It can be set up at the treatment / disposal and landfill site for the municipal garbage, with adequate precaution and control.

7.9.1 Establishment of the Facility

The common treatment/disposal facility, as the name suggests, would consist of (i) the treatment unit(s) and (ii) a sanitary/secured landfill for the final disposal of the treated residues and incinerator ash. The treatment chain, of necessity would consist of a properly designed incinerator (especially for human anatomical waste) and other systems such as autoclave/ hydroclave/ micro-wave unit etc. Chemical treatment units may also be added if felt necessary.

The treatment part can also be a mobile facility, with the incinerator and the landfill located conveniently at one place. Usually these are large vans (as shown in the picture) housing small equipment for size reduction and micro-wave / chemical treatment. The van moves along a pre-planned route and is occasionally parked in certain zones, where it receives the bio-medical waste and treats the components which, according to the prevailing rules can be subjected to micro-wave treatment. Finally it reaches the static facility for incineration of human anatomical waste and for secured landfilling of mutilated sharps and other final disposable items.

The concerned medical establishments should establish such facilities by creating a common pool and platform. Proper planning followed by preparation of a feasibility report is necessary. The fund for capital investment may be raised by proportional contribution from participating institutions. The cost of operation & maintenance (O&M) may be met by monthly billing against advance deposit.

Alternatively, private entrepreneurs may be encouraged to set up such facility on build, own, operate (BOO) basis (section 7.9.3).

The State Health Authority or the Civic Authority may consider to establish at least one full-fledged facility with its own investment and operate the same through private operators on full cost recovery (capital as well as O&M) basis. Such a facility may act as a catalyst and a model for replication.

7.9.2 Tie Up of Health Care Set Ups

A clear decision has to be taken first regarding the model to be adopted, viz., Build, own and operate (BOO), Build, own and transfer (BOT), Build, own, operate and maintain (BOOM) etc. For a lasting tie up and smooth functioning of the common treatment and disposal facility, the following points must be considered :

1. Legal aspects
   - Formulation and signing of a valid contract between the concerned parties, i.e., the health care establishments.
   - Permission from the concerned authorities, as per existing Government notification, e.g., Prescribed Authority (Pollution Control Board or other authorities notified by the State Govt.)

2. Financial aspects
   - Costing of the whole system (capital cost, depreciation, O&M cost, interest and debt servicing etc.).
   - Working out proportional contribution for capital investment.
   - Evolving a cost sharing mechanism. For example a system of advance deposit and monthly billing for full cost recovery of all recurring cost, as mentioned above.

3. Managerial aspects – Formation of an action committee / group to facilitate day to day management and monitoring of the facility. In case O&M is handed over to a third party, this committee should be able to safeguard the interests of the participating institutions.

7.9.3 Private Sector Participation

This being a highly specialised and specific job, involvement of specialised agencies would be necessary. Private entrepreneurs with adequate background and capability may be encouraged to take up and organise such ventures. The health care establishments may find it much more workable to hand over the day to day O&M to a private concern rather than doing it on their own. In this case, proper contract agreement must be made with the party with necessary terms and conditions and safeguards (as mentioned above at 7.9.2).

7.10 OPERATION AND MAINTENANCE

Once the bio-medical waste management system is in place, its operation and maintenance assumes crucial importance.

The administration of the establishment, whether big or small, should provide written instructions to all the departments generating or managing waste, stating the policy of the organisation and the decisions taken which are to be adhered to. Charts and schedules should be made with the help of experts/consultants and displayed at strategic points.

Co-ordination between the civic authority and the common treatment / disposal facility is extremely important for timely removal of the waste. There should be no confusion regarding placement of the waste components, their containers and colour coding, removal schedule etc.

Monitoring of the whole process, whether in-house or out side the hospital, is essential. Monitoring schedules for both must be made. Contingency plan needs to be prepared in case there is any problem or difficulty in carrying out the assigned jobs.

7.11 OCCUPATIONAL HAZARDS AND SAFETY MEASURES

The staff of the health care establishments, who are either in contact with the patient or the infectious waste generated, are continuously at risk during their working hours. Therefore it is essential that adequate protection measures are provided against occupational health hazards. The administration of the health care establishment (Infection Control Officer in case of large ones) should have a detailed deliberation on this subject.

7.11.1 Occupational Hazards

The following types of occupational hazards occur / can occur in case of medical/para-medical personnel or staff involved with cleaning/collection or transportation of waste etc.:

- Accidental cut or punctures from infected sharps such as, hypodermic needles, scalpels, knives etc.
- Contact with infected material like pathological waste, used gloves, tubing etc., especially from the operation theatre.
- Bedding and dress material of the patient or from the doctors (used during check up/ surgery etc.)
- Contact with stool, urine, blood, pus etc of the patients during cleaning job.

7.11.2 Safety Measures for the Medical and Para-medical Staff

The following instructions need to be notified and strictly adhered to :

- Clear directives in the form of a notice to be displayed in all concerned areas.
- Issuance of all protective clothes such as, gloves, aprons, masks etc. without fail.
- Sterilisation of all equipment and issue of only properly sterilised equipment and tool, such as, surgical tools to the medical personnel. Maintenance of registers for this purpose.
- Provision of disinfectant, soap etc of the right quality and clean towels/tissue paper.
- Regular medical check-up (half-early).

7.11.3 Safety Measures for Cleaning and Transportation Staff

- Display of illustrated notices with clear instructions for do’s and don’ts in Hindi and the local language.
- Issuance of all protective gears such as, gloves, aprons, masks, gum boot etc. without fail.
- Provision of disinfectant, soap etc of the right quality and clean towels.
- Provision of a wash area, where they can take bath, if needed/desired.

- Washing and disinfecting facility for the cleaning equipment and tools.
- Regular medical check-up (at least half-yearly).

7.12 FINANCIAL ASPECTS

Compared to the cost of medical facilities, capital as well as operation and maintenance, the additional cost required for a proper bio-medical waste management is not high. The following points are important for consideration :

- Provision of proper management of bio-medical waste is mandatory now under the Bio-medical Waste (Management & Handling) Rules, 1998 apart from being a social and ethical obligation of the concerned organisations and individuals.
- With the introduction of a streamlined system, better control of man and material and avoided cost of accidents and compensation, it should be normally possible to make some savings.
- Mobilisation of resources, such as loans, grants and own contribution for making capital investments. The possibility of introducing a small incremental charge over the existing service charges for various medical facilities for meeting O&M cost and debt servicing may be explored.
- In case of Common Treatment Facility, similar considerations have to be deliberated upon by the concerned institutions. In case, the civic authority decides to set up the facility from its own resources or through loan (BOT or BOOT model), proportional charges, incorporating capital as well as O&M cost has to be levied from the user institutions. If private capital be involved for making a BOO model, similar considerations would still be valid but the transactions would be between the concerned parties and the facility. In this case, the civic authority may provide land on lease and levy a suitable lease charge.
- Finance (loan) is available from Financial Institutions.

7.13 TRAINING AND MOTIVATION

The training programme aims at sensitising the management and equipping the medical, para-medical and auxiliary staff with necessary working knowledge and clear instructions about their respective roles. At the same time a core group of trainers should be organised for continued in-house training of the auxiliary and sanitation staff. For the success of the programme, it is essential that training and orientation courses are planned for the following categories of functionaries and people according to their qualification and experience, their role and responsibility:

- Policy Makers
- Civic Authorities
- Hospital Administration, Medical Superintendent, Deans and Head of the Departments
- Doctors, surgeons and specialists
- Auxiliary and nursing staff
- Ward boys and cleaning/sanitation staff

The training programme for the various categories need to be repeated, especially for the auxiliary staff. The interval between two programmes has to be decided by the management, depending upon available staff strength, resources etc.

7.13.1 Training Modules for Different Levels of Staff

Training modules should be developed for the following category of personnel :

- Medical and laboratory personnel
- Para-medical personnel, e.g., nurses, ward boys etc.
- Sweepers/cleaning staff, guards etc.
- Administrative and management staff

Each category has different duties and accordingly, they should (i) understand their specific role regarding waste management, (ii) comply with the policy decisions taken by the management of the establishment and (iii) contribute to the success and betterment of the overall bio-medical waste management plan in their own health care establishment as well as in their town.

(i) Medical and laboratory personnel:

This training capsule should include :

- Detailed discussion regarding the existing rules and regulations, supply of copies of the rules to each individual.

- Review of the hazards and impact of improper management of bio-medical waste, siting case studies if possible.
- Discussion regarding the policy of the specific health care establishment.
- Detailed description of each step involved, including use of equipment and tools (for example, needle cutter/melter, containers for used sharps, sterilising equipment etc.), use of forms, monitoring etc.
- Discussion regarding their specific role.
- Measures for accidents, incidents and emergency situations (regarding hospital waste management).
- Comments and suggestions which subsequently be considered for the success and betterment of the system.

(ii) Para-medical personnel:

This training capsule should include :

- Health hazards and impact of improper management of bio-medical waste, implication of neglect and not following the instructions, examples.
- Brief outline regarding the existing rules in simple language which they can understand.
- Supply of relevant charts indicating the practical implications of the rules and the policy of the hospital management.
- Detailed description of each step involved from their point of view.
- Discussions and instructions regarding their specific role and activities in this respect.
- Do’s and don’ts regarding bio-medical waste management.
- Measures to be taken during accidents/ incidents/emergency situations.
- Incentives and punishments.
- Comments and suggestions.

(iii) Sweepers, cleaning staff, guards etc.:

This training should preferably be carried out in the local language. The material for this category may contain the following :

- Awareness generation, highlighting the importance of proper management of infectious and hazardous bio-medical waste and the health hazards and diseases caused by them.
- A brief introduction of the rules framed by the Ministry of Environment and Forests, Government of India and the advantages in following them.
- Providing them simple illustrated charts showing their responsibilities, the pit falls, how to be vigilant (especially for the guards).
- How to cope with accidents / incidents related to infectious, toxic and hazardous waste, how to help their colleagues in such situations.
- How to maintain personal hygiene in the environment of a health care establishment, the use and importance of protective gear such as, gloves, gum-boots, mask, apron etc. as well as of disinfectant and soap.
- How to co-operate with the management in this matter and how to report in case of any problem.
- The incentives and punishments programme of the management.

(iv) Administrative and management staff:

This capsule would contain material for awareness generation, the responsibilities and accountabilities formulation of policy.

- Awareness generation, highlighting the social, ethical and legal responsibilities of the management, case studies.
- Discussion on the Bio-medical Waste (Management and Handling) Rules, 1998, emphasising the legal, financial and contractual issues.
- The steps required for formulating a policy for the specific health care establishment, keeping in view the Govt. rules.
- Co-ordination with the civic and health authorities as well as with the prescribed authority of the State.
- Administrative and managerial support mechanism necessary for implementing and sustaining a proper bio-medical waste management system.
- How to motivate and elicit co-operation from various staff members.
- The concept of common treatment facility – the legal, financial and contractual issues.

7.13.2 Incentives and Motivation

These are important components for the success of the programme. Awards and punishments – both are required for this purpose. The following steps are recommended :

- The medical, surgical, laboratory and research staff should be encouraged to think on this problem and suggest innovative ideas/ designs/systems etc., which may be adopted for improvement in the waste management situation. Suitable awards may be instituted for this purpose.
- Similarly, the nursing and the auxiliary staff may also be encouraged to suggest practical ideas for improvement in their sphere of activities.
- Awards should be instituted on annual basis for the sanitation staff for the best work in each ward/ suitable units.
- Awards may also be instituted for the most hygienic and clean department for which the award may be given to the respective team.
- Punishment for dereliction of duty and non compliance or not obeying the orders / directives should be decided in advance and notified prominently. Prompt action should be taken for such lapses.

7.13.3 Awareness Generation

Sustained awareness generation is essential. The management of the hospital should organise awareness programmes, especially for the auxiliary staff. Debates, drama, essay competition etc. may be considered for this purpose.

7.14 PLANNING ELEMENTS

From a planner's point of view, the topic of hospital waste management may be divided into two parts :

(i) Internal (planning of the hospital/nursing home, various movement routs, service corridors, storage area for hospital waste, treatment site if so planned, availability of open area, buffer zone etc.).

(ii) External (for off-site treatment/disposal, common treatment/disposal facility) - site selection for such facilities according to land use plan, transfer route etc. of the town.

These have been outlined keeping in view the requirements at the time of initial planning, but some of these may be valid for existing facilities or for the purpose of expansion / extension.

7.14.1 Planning Inside the Health Care Establishment Premises

The hospital buildings are broadly divided into three parts/areas : Out Patient Department (OPD), Investigative facility area and In-patient department. OPD deals with patients on their first contact and those who do not need to be admitted in the hospital. It also has an Emergency unit, which takes care of patients under trauma, injury or other life threatening emergencies. This area generates bio-medical waste. The investigative area contains Operating Theatre (OT), investigating equipment like X-ray, Ultra sound, Electro Cardio Gram (ECG), stress tests (including Thallium stress test, which uses radioactive compound), bio-chemical/pathological laboratory etc. and is usually sandwiched between the OPD and the In-patient department (wards). The investigative area and the wards are the main generators of hazardous and bio-medical waste in the health care establishments. Other important utility areas in a hospital are the laundry, chemist's counter etc.

- In general, an attempt should be made to keep the areas generating infectious and hazardous waste (OT, maternity area, emergency area, infectious disease area, isolation area etc.) separated from those which generate non-hazardous waste (administration/office, kitchen, store etc.) so that there is a broad demarcation and proper management of waste becomes more effective and more convenient.
- Each point of waste generation should have adequate storage space for storing different kinds of waste matter. This should include any exigencies so that the system does not fail. For areas, which have potential to generate more infectious and hazardous waste, twice the average requirement should be taken. The storage area should be easily accessible from the service corridors meant for this specific purpose (discussed below).
- Arrangement for separate receptacles in the storage area with prominent display of colour code on the wall nearest to the receptacles.
- Separate service corridors for taking waste matter from the storage area to the collection room must be provided. These corridors should not cross the paths used by patients and visitors.
- Collection room (s) where the waste packets/bags are collected before they are finally taken/transported to the treatment/disposal site. This is more important when the waste is to be taken outside the premises. Two rooms - one for the general and the other for the hazardous waste are preferable.

The latter should be secured, cool and provided with fine wire mesh to prevent access of flies, mosquitoes etc. Proper gradient and drains should be provided so that this area can be cleaned and washed daily. In the event of shortage of rooms, the general waste (non-hazardous) can be directly stored outside in dumper containers (with lids) of suitable size.

- A shed with fencing should be provided for the carts, trolleys, covered vehicles etc. used for collecting or moving the waste material. Care has to be taken to provide separate sheds for the hazardous and non-hazardous waste so that there is no chance of cross contamination. Both the sheds should have a wash area provided with adequate water jets, drains, raised platform and protection walls to contain splash of water.
- If treatment of the hazardous/bio-medical waste is planned within the hospital premises, then its location has to be considered very carefully.
- If incineration is the chosen technology, it has to be installed at a place where there is least chance of contamination or pollution, especially from the emission, either for the hospital or its surroundings. Normally it should be away from the main building but should have sufficient buffer zone from the outside buildings, roads etc. so that there is no real or ethical nuisance perception. The recommended stack height (minimum 30 metres) has to be followed. In some hospitals in high-density areas, incinerators have been installed on the roof top to save space and to have extra stack / chimney height with relation to the ground. But such practices are fraught with danger unless very careful planning is done for fire fighting, movement of hazardous waste with separate lifts, safe removal of ash etc.
- If autoclave technology is chosen for treatment, then a decision has to be taken whether the boiler used by the laundry would also be used for the autoclave or a separate boiler would be installed. Accordingly, the equipment may be housed near the boiler of the laundry. However, these areas must be separated by a wall so that there is no chance of contamination of the laundry area. Only steam pipes (properly insulated) have to pass through the dividing wall. Proper drainage and outlet for spent steam / gases (with adequate filter elements) have to be provided. The steam condensate should be put in the underground sewer, after cooling, if necessary. The facility should be well connected with special service corridors for bringing the hazardous material and also for removal of the treated waste.
- Hydroclave technology, which is somewhat similar to the autoclave, requires less steam (only for the outer jacket and occasional supplementary steam for the main vessel in case of very dry waste) from an external source. Hence its proximity to a boiler is not a necessity. Small dedicated steam generators may also be installed for small to medium size facility.

- If Microwave technology is chosen, then also, the installation can be suitably at one side of the building or a separate building. Other conditions are the same as those for the hydroclave.
- The hospital may like to have its own secured disposal sites within the premises for sharps, incinerator ash, treated denatured waste etc. Such facilities should be planned after appropriate site qualification (at a mini scale), such as, distance from water sources, accessibility of birds, rats, vermin etc. as well as ragpickers, children and visitors.
- Separate roads and entry/exit gates should be provided for taking out the hospital waste, be it general waste or treated waste or incinerator ash.

7.14.2 Planning Outside the Health Care Establishment

The main concerns outside the establishment are - siting of common treatment facility and secured engineered landfills for sharps, incinerator ash and similar hazardous material for their ultimate disposal.

- Common treatment facilities should be planned with an eye at the future development prospects of the town/city. The sites have to be properly evaluated from the environmental angle as well as location of the clients (health care establishments). As mentioned earlier (7.9), the local landfill site may also be considered for installation of the common treatment facility.
- The ultimate disposal site for incinerator ash, sharps, toxic matter etc. should be planned in the same way as a secured landfill site is made for other toxic and hazardous waste. In fact, the local body (municipality) may consider to have a secured landfill site for all hazardous substances within its boundaries and allow its use on payment of charges / cost sharing basis.

7.14.3 Relation to Overall Town Planning

Proper planning, whether at the hospital (or other health care establishment) level or at the town planning level, is of utmost importance. Obviously, the best and the most effective system can evolve in an establishment, where the building itself has been designed accordingly. Similarly, it would be prudent to consider the points involved for siting of common treatment/disposal facility in the town-planning document. Then only optimal solutions and results can be expected.

7.14.4 Examples

Authentic data is still not available. However, estimated amounts have been taken here for working out the examples.

50 bed hospital/nursing home :

- Estimated generation of total waste @ 1.5 kg/bed - 75 kg/day
- Estimated generation of bio-medical waste @ 25% of the total waste generated - 18-20 kg/day

Waste management system :

1. **Bio-medical waste** - Segregated storage at source in coloured plastic bags (according to the rules) which are to be kept inside sturdy covered containers. For collection, dedicated wheel-barrows are to be used for carrying the containers directly to the storage area. For transportation, covered vans are to be used as indicated under section 7.7.4. For treatment and disposal, the bio-medical waste should be taken to a common treatment and disposal facility having incineration facility also. Till the common treatment facility is in place, the bio-medical waste should be properly put in secured pits at the landfill site as shown in the figure 7.1 and the sharps in a covered pit which can even be located within the premises if suitable space is available.

2. **General waste** (not infected or hazardous)

   (a) Dry waste from office, store etc. to be kept segregated and sold to the recycling chain existing in the town.

   (b) Wet biodegradable waste from kitchen, garden etc., which are not infected, should be put into the municipal collection system.

200 bed hospital/nursing home :

- Estimated generation of total waste @ 1.5 kg/bed - 300 kg/day
- Estimated generation of bio-medical waste @ 25% Of the total waste generated - 75-80 kg/day

Waste management system :

1. **Bio-medical waste** - Collection as above. The size of the carts should be according to the necessity. Treatment and disposal may be through common treatment and disposal facility as mentioned above. Alternatively, autoclave/microwave facility of suitable size may be installed if so desired. But installation of incinerator should only be planned if sufficient buffer zone is available around the facility.

2. **General waste** - As mentioned above. However, in this case, composting of garden and other bio-degradable waste may be undertaken if suitable land and trained manpower who can do the job in a proper manner is available without causing any degradation to the environment.

Examples of Common Treatment Facilities:

1. For 15000 beds (corresponding to about 40-50 lakh population)

Expected total waste generated : 20-25 TPD (approx.)
Expected generation of bio-medical waste : 5-6 TPD (approx.)

The common treatment facility may contain the following :

- Incinerator (preferably with a standby), compatible with the new emission norms, capacity 100 kg./hr., to be run in 3 shifts – for anatomical/pathological waste and cyto-toxic drugs.
- Autoclave/ hydroclave/ micro-wave equipment, compatible with the rules, capacity 100 kg./hr., to be run in 2-3 shifts – for soiled waste, solid waste, waste sharps and microbiology/biotechnology waste. A shredder may be installed with hydroclave for further shredding of the treated material if so desired.

- Sanitary landfill for incinerator ash, treated material from autoclave/ hydroclave and other waste material which are not contaminated /infected.
- Secured pits for sharps.

2. For 5000 beds (corresponding to 10-15 lakh population):

Expected total waste generated : 4-5 TPD (approx.)
Expected generation of bio-medical waste : 1-1.5 TPD (approx.)

The common treatment facility may contain the following :

- Incinerator (preferably with a standby), compatible with the new emission norms, capacity 30-35 kg. /hr., to be run in 3 shifts – for anatomical /pathological waste and cyto-toxic drugs.
- Autoclave/hydroclave/micro-wave equipment, compatible with the rules, capacity 30-35 kg./hr., to be run in 2-3 shifts – for soiled waste, solid waste, waste sharps and microbiology /biotechnology waste. A shredder may be installed with hydroclave for further shredding of the treated material, if so desired.
- Sanitary landfill for incinerator ash, treated material from autoclave/ hydroclave and other waste material which are not contaminated /infected.
- Secured pits for sharps.

7.15 MANAGEMENT ASPECTS

From the planning stage to day to day execution of a proper waste management system in the health care establishments, management aspects are of crucial importance. The management of waste requires continuous involvement of a long chain of people, such as, doctors, nurses, ward boys, cleaning staff etc. Dereliction of duty and carelessness at any stage can affect or even spoil the whole system. Therefore, all staff should know about their precise role – what is expected of them and why it is important for them to act according to the directions given to them.

According to a recent World Health Organisation (WHO) publication "Safe Management of Waste from Health-care activities", apart from categorisation, assessment of current situation, the management of the hospital should develop and implement an effective Waste Management Programme.

7.15.1 Organisational Set Up

The above-mentioned document of WHO clearly lays down that the Head of the Hospital should form a Waste Management Team to develop and implement the Waste Management Programme. The team should have the following members:-

- Head of Hospital (as Chairperson)
- Head of Hospital Departments
- Infection Control Officer
- Chief Pharmacist
- Radiation Officer
- Matron (or Senior Nursing Officer)
- Hospital Manager
- Hospital Engineer
- Financial Controller
- Waste Management Officer (if already designated)

The structure is indicated in Fig.7.1

The Waste Management Committee should regularly meet at least once a month to review and make recommendations directly to the Hospital Director regarding any changes in the Management, Purchase Procedures, Training, Review and Remedial Measures for compliance of the Bio-medical Waste (Management and Handling) Rules, 1998 etc. All these recommendations should be duly documented.

7.15.2 Administration and Managerial Aspects

The management of the health care establishment should make an action plan to implement the recommendations of the rules framed by the Government of India (Ministry of Environment of Forests). This would include the following :

- Formation of a Waste Management Committee as outlined above.
- Clear indication of the role of each member of the committee.

- Action Plan for proper waste management in the particular health care establishment and its documentation. This plan should be reviewed once a year.
- Development of a format for reporting accidents and incidents relating to bio-medical waste management and its meticulous following.
- Assessment of all the survey results and their utilisation – once in every 6 months

7.16 ANIMAL WASTE

Animal waste comprises animal tissue, organs, body parts, experimental animal carcasses (used for research), animal waste from veterinary hospitals, animal houses etc.

According to Schedule I of the Bio-medical Waste (Management and Handling) Rules, 1998, these wastes fall under Category 2. According to these rules, such waste has to be incinerated. In towns with population less than 5 lakh, such waste can be subjected to deep burial. The pits for deep burial have to be in accordance with the specification given in Schedule V of the Rules.

In towns having more than 5 lakh population, the animal waste can be sent to the Common Treatment Facility meant for other type of bio-medical waste and incinerated there. The animal waste must be put in leak proof bags and should be transported safely taking precautionary measures as detailed in section 7.7. For further details, refer Chapter 5 .

CHAPTER 8
SORTING AND MATERIAL RECOVERY

8.1 INTRODUCTION

The term 'sorting' indicates separation and storage of individual constituents of waste material. In this chapter, the term 'sorting' is used synonymously with 'separation' and 'segregation'.

8.2 OBJECTIVES OF SORTING

The following are the objectives of sorting in the Indian context:

(a) To separately store recyclable material for reuse.

(b) To ensure that waste which can be processed for recovery of material and energy (through composting, incineration or any other suitable technology) does not become co-mixed with undesirable elements.

(c) To separately store hazardous material for disposal in hazardous waste landfills or appropriate processing.

(d) To minimise the waste and ensure reduction in landfill space for final disposal

8.3 STAGES OF SORTING

There are various stages at which sorting can take place in the waste stream. These can be identified as the following:

(a) At the source / household level

(b) At the community bin (municipal bin)

(c) At a transfer station or centralised sorting facility

(d) At waste processing site (pre-sorting and post-sorting)

(e) At the landfill site

8.4 SORTED WASTE STREAMS

Sorting is carried out to segregate the waste into different streams to fulfil one or more of the objectives listed above. Accordingly the waste should be divided into the following streams:

(a) Dry Recyclables

(b) Construction and demolition waste

(c) Biodegradable waste

(d) Bulky waste (white goods)

(e) Hazardous waste

(f) Mixed MSW (often referred to as comingled waste)

8.5 SORTING OPERATIONS

Sorting can be carried out manually or through semi-mechanised and fully mechanised systems

Manual sorting operations comprise of

(a) unloading the waste

(b) manually (with protective measures) spreading the waste

(c) hand picking (with protective measures) visually identifiable waste for reuse

(d) collecting and stockpiling the remaining waste.

Semi-mechanised sorting operations comprise of

(a) unloading of waste (mechanised)

(b) loading of waste on conveyor belts (mechanised)

(c) hand picking of visually identifiable waste off the belt for reuse (manual)

(d) collecting, stocking and reloading the remaining waste (mechanised)

Fully mechanised sorting operations comprise of

(a) unloading of waste

(b) size reduction of waste through shredders and crushers

(c) size separation of waste using screening devices

(d) density separation (air classification) of waste

(e) magnetic separation of waste

(f) compaction of waste through balers/crushers

(g) reloading of waste

Semi - mechanised and fully mechanised systems are used at central sorting facilities. In semi-mechanised systems, productivity of sorters can be of the order of 5 tonnes of sorted material per person per day (Table 8.1).

Table 8.1: Productivity of Manual Sorters by Picking Off A Conveyor Belt in a Semi-Mechanised System

Material	Average tonnes/person/day	Range tonnes/person/day
Paper	7.58	8.36 – 13.05
Metals	6.06	1.21 – 17.53
Glass	8.28	1.02 – 16.11
Plastics	1.60	0.60 – 3.21
Average	5.12	2.69 – 8.88

Source : "Integrated Solid Waste management" – A Life Cycle Inventory" . White et al (1995), Chapman & Hall, London

A typical example of a combination of manual and mechanical sorting flow chart (mass balance) adopted at a central sorting facility in a developed country is shown in Fig. 8.1 for 1000 tonnes per day waste generation.

8.6 CURRENT STATUS

Waste is currently sorted out, but not necessarily in the required waste streams. It is important to examine the current status of sorting before embarking on a series of guidelines to prescribe what needs to be done.

Household waste sorting in India is a complex activity which involves more than one sector and more than one location. For the sake of understanding it is convenient to divide it into primary level sorting and secondary/tertiary level sorting.

8.6.1 Primary and Secondary/Tertiary Sorting

Currently sorting of household waste is carried out both at the household level by the inmates and at the common bin level by ragpickers. This seems to be the general picture around the country except in few instances where NGO (Non-Governmental Organisation) or municipality intervention has attempted to introduce household sorting on a more intensive level.

Primary sorting is carried out both within the household, and at the municipal bin or at the final disposal site such as the landfill, or waste dump.

Further or secondary /tertiary sorting is carried out in the recycling trade chain by kabaris and middlemen.

8.6.2 Primary Sorting at Source

There is a tradition in households in Indian cities to keep aside items like newspapers, used bottles, jars, pesticide cans, old clothes, rags, broken and old white goods, strong plastic bags etc. and not mix them with other everyday household wastes. These are used as items of economic value, to be sold or just as give-aways. The waste here is normally dry and capable of being easily and safely stored.

Garden waste is also separate from household waste, in houses which have greenery. However since there is no separate mechanism for its collection or disposal, it ends up being mixed with the municipal waste.

8.6.3 Primary Sorting at The Community Bin (Municipal Bin)

What then finds its way to the municipal bin is kitchen waste, thin plastic bags, used paper, some amount of other paper and plastic packaging, glass such as old bulbs and florescent tubes, used batteries, household medical waste, used diapers and sanitary napkins, used beverage cans and such like. The bulk of this is food waste.

At the municipal bin, the informal sector, spearheaded by the ragpicker as its front-line collector takes over. The items most often collected are some types of plastics, mostly mineral bottles and stronger plastic bags, paper, rags, metal cans, rubber items etc.

8.6.4 Primary Sorting at the Landfill

Ragpicking also continues at the landfill level. Here ragpickers who do not have access to city municipal bins, pick out even those wastes which are left behind or overlooked at the municipal bin. It is not unusual to see a trail of ragpickers collecting items raked up in the wake of the bulldozer which is compacting the landfill. Here the items found of value and hence collected, include small metal pieces like nails - collected by a stick topped with a magnet-soggy and thin plastic bags which are washed and dried, any other bits and pieces which would yield some financial returns.

At all levels the general categories of items not collected are construction debris, hazardous wastes like used batteries, infectious wastes such as bandages, cotton, napkins, or non- recyclable wastes such as some types of plastics or packaging.

It is then obvious that the degree of sorting as carried out by the informal sector and the householder at present is extremely intensive, and only those items are being left out for which there is almost no possibility of reuse or recycling. As such, this system is very different from that in more developed countries.

8.6.5 Secondary and Tertiary Sorting

After the waste which has been sorted into main categories at the primary level reaches the first informal recycling trade middleman - the kabari's warehouse, more detailed sorting is carried out. Hence all metals, types of plastics, types of paper such as newspaper, magazines etc. are segregated. This waste then is bought by the larger wholesaler, who does more than sorting, since he is the final link between the recycling factory and the kabari, and can extend business terms like credit, hedging for better pricing etc. It is not necessary that there always be a tertiary level in the materials chain, and both secondary and tertiary levels can simultaneously co-exist in a particular material stream.

8.6.6 Occupational Health

At the municipal bin level, injuries and infection can be caused to ragpickers. There have been a few studies done on the occupational health risk to ragpickers, and injury rates can go upto 6 per month. They have also been found to have infected wounds, sore feet, but no specific study has been done which isolates health effects such as an increased incidence of illness directly attributable to waste, and not other socio-economic factors. Some studies are also currently under progress. It is however not wrong to presume that their occupation risk owing to injury and disease transmission through waste is higher, and one of the first reaction of any municipality in the event of an epidemic has been to deny ragpickers access to the waste bins - and their livelihoods.

8.7 TOXICITY RELATED HAZARDS

Table 8.2 lists typical hazardous products found in co-mingled municipal solid waste.

Table 8.2: Hazardous Products in Municipal Solid Waste

Product	Concern
Household cleaners	
Abrasive scouring powders	Corrosive
Aerosols	Flammable
Ammonia and Ammonia based cleaners	Corrosive
Chlorine bleach	Corrosive
Drain openers	Corrosive
Furniture polish	Flammable
Glass cleaners	Irritant
Outdated medicines	Hazardous to others in family
Oven cleaner	Corrosive
Shoe polish	Flammable
Silver polish	Flammable
Spot remover	Flammable
Toilet bowl cleaner	Corrosive
Upholstery and carpet cleaner	Flammable and/or Corrosive
Personal care products	
Hair-waving lotions	Poison
Medicated shampoos	Poison
Nail polish remover	Poison , flammable
Rubbing alchohol	Poison
Automotive products	
Antifreeze	Poison
Brake and Transmission fluid	Flammable
Car batteries	Corrosive
Diesel fuel	Flammable
Kerosene	Flammable
Gasoline	Flammable, poison
Waste oil	Flammable

Paint products	
Enamel, oil-based, latex or water-based paints	Flammable
Paint solvents and thinners	Flammable
Miscellaneous products	
Batteries	Corrosive
Photographic chemicals	Corrosive, poison
Pool acids and chlorine	Corrosive
Pesticides, Herbicides and Fertilizers including garden insecticides, ant and cockroach killers, weed killers, etc.	Poison, some are flammable
Chemical fertilizers	Poison
Houseplant insecticide	Poison

Source : "Integrated Solid Waste Management" Tchobanoglous et al (1993), Mc. Graw Hill, New York

8.7.1 Hazardous Substance Containers

Large to medium-sized old pesticide cans, used aerosol cans etc. are sold by households mostly directly to the kabari. These are either used to reclaim the metal or reused as water containers etc. Both practices are hazardous, but there is very little awareness of this.

8.7.2 Household Batteries and Other Toxic Wastes

There is currently no separate collection mechanism for any other household toxic waste. Items here would include household batteries, small-sized paint cans, broken thermometers, household chemicals etc. The collection system does not exist since there are no plants to recycle these, and also since there are no producer take-back mechanisms in place.

8.7.3 Infectious Wastes

Household infectious wastes consists of home care items such as bandages, cotton, needles used for insulin and other purposes, sanitary napkins etc. There is no segregation of these wastes nor any mechanism for disinfection before disposal.

8.8 NON-RECYCLABLE PACKAGING

Many items are left out from the collection system, since the informal sector either does not have the technology to process or recycle them or it is not paying enough for the ragpicker to collect them. Examples of the first would include new types of multi-layered or multi-material packaging such as tetrapacks, medicine packaging, squeezable tubes, laminated packaging, plastics like Poly Ethylene Terethalate (PET) etc.

The second category, i.e. uneconomic to collect, would include soggy paper, crushed glass, fluorescent tubes, used batteries, thin plastic carry bags, which are of minimum or no economic value. Of these carry bags are worth a special mention since they have become a source of country wide citizen's protests. These bags, being very thin, require a large number to be collected before they make up a sellable weight. Since the ragpicker normally gets paid per kilo of plastic collected, it would take him/her all morning to collect 800 bags needed to make up one kilo to fetch a paltry 2 to 3 rupees. On the other hand, heavier plastics would be faster and easier to collect.

8.9 PROBLEMS AND DESIRABLE CHANGE

The main problems of sorting of waste as it is carried out manually at various stages listed in section 8.3 are:

(a) Waste gets scattered at the bins.

(b) The sorting itself entails rummaging through waste by ragpickers exposing them injuries through cut glass, metals as well as diseases through household infected waste as well as medical waste in case it has been mixed.

(c) Some types of waste does not get recycled, since it is not currently recyclable.

(d) Toxic or hazardous waste does not get collected and ends up either in landfills or in composting operations. Both cause other contamination such as of groundwater or of the compost.

(e) Recycling takes place in very poor health and environmentally unsafe conditions.

8.9.1 Long Term Desirable Change

Sorting at the levels at which it is currently being carried out is quite efficient except for some types of wastes. It may be desirable to keep this intact. Shifting of sorting to more centralised locations would mean transferring more waste to them as well as ensuring that waste is not picked beforehand - which would be rather difficult to do.

The current system is very intensive and also provides employment to a large number or persons. It is estimated that in Delhi alone more than 100,000 persons are engaged in the collection and recycling activity. However it must be realised that this system is exploiting the labour conditions and flouts all laws of child labour, wage payment, worker benefit, occupational safety, and environmental norms for the recycling units. Hence though extremely efficient and desirable, it has to be approached with caution in terms of interventions.

It would naturally follow that if all the conditions for formal sector labour are met in the informal sector, the cost of the system would increase. Such a cost would need larger economies of scale of recycling units, and better product quality to be able to recover the cost. It would also extend to investment in recycling facilities of those items which are not currently recycled and the ability to handle hazardous waste streams.

The only manner in which to carry this out is to impact a structural readjustment of the recycling sector with a producer responsibility built in. Hence recycling of batteries may need investment into this sector by the battery producer. Such systems are prevalent in more developed economies including for bulky goods such as cars. Normally this would also entail the setting up of recycling laws and working out a system of subsidies and tariffs to ensure that this is economic to do for all concerned.

However, it must also be ensured that the persons already engaged into the trade are protected in terms of their livelihoods, which calls for a gradual and incremental approach.

The following long-term changes are desirable:

(a) An organised colony-wise collection system involving ragpickers, with proper gear and protection.

(b) Investments in the recycling sector to ensure that the units are safe and operate at economic scales.

(c) Augmentation of the material recycling trade through implementation of laws.

(d) Development of recycling laws for specific types of wastes.

(e) Incorporation of producer responsibility for collection and disposal or recycling of specific types of wastes, especially hazardous wastes.

(f) Promotion of simple disinfection techniques and devices such as needle cutter for infectious waste to be pre-treated before disposal.

(g) Maintenance of the existing kabari system.

(h) Pre-sorting of waste for composting operations, through mechanical means..

8.10 GUIDELINES FOR SORTING FOR MATERIAL RECOVERY

8.10.1 General

(a) Sorting of the waste at the source must be accorded the highest priority by the urban local bodies.

(b) The existing system of the kabari-wallah, which efficiently recovers the dry-recyclables and bulky waste (white goods) from the source, must be facilitated.

(c) The role of ragpickers in collecting and recovering recyclables (not taken by the kabariwallah) must be recognised and strengthened at the community level by using their services at the household/source level with the help of NGOs/private sector participation.

(d) Municipalities must have separate waste collection, transportation and disposal streams for:
   (i) Biodegradable waste
   (ii) Mixed waste (comingled waste)
   (iii) Construction and demolition waste
   (iv) Hazardous waste

(e) Biodegradable waste should be used for biological processing at a central facility/ decentralised facility.

(f) Construction and demolition waste should be processed for re-use or stored in landfill cells capable of being mined for reuse.

(g) Hazardous waste should be transferred to hazardous waste landfill or processed appropriately.

(h) Horticulture waste from parks and gardens should be composted at the site or at a decentralised facility to be operated by the municipality.

(i) Mixed waste (comingled waste) should be sorted into the various streams listed in section 8.8 either at a transfer station or at a centralised sorting facility. If this is not feasible, mixed waste can be sent to a processing facility which has a well designed pre-sorting/post-sorting facility where the mixed waste can be sorted into separate streams. Mixed waste not found suitable for processing should be landfilled.

Fig. 8.2 shows the role of sorting at various stages. Fig.8.3 shows the importance of pre-sorting in waste management, where mixed waste reaches a waste processing facility.

8.10.2 At the Source

(a) It should be mandatory that all hazardous waste as listed in Table 8.2 is stored separately at source and not mixed with the other wastes. This should be periodically collected by the municipality from the household level or collected by them at a local collection centre designated for this purpose. In the long-term perspective such a system must move towards laws where manufacturers are expected to collect the hazardous waste resulting from their product at the source or through a suitable collection system.

(b) It is desirable that those dry recyclables which are not collected by a kabari-wallah are stored separately at the source and collected (once or twice a week) by a waste collector who may be the same person as the ragpicker at the community municipal bin. To initiate separate storage at source and subsequent collection of such waste by the existing network of rag pickers, help may be taken from NGOs in the short-term.

(c) Construction and demolition waste must be stored separately at the source and deposited at sites identified by the municipal authority or collected periodically by the municipal authorities (or an agency designated by them) on payment basis.

8.10.3 At the Community Bin (Municipal Bin)/ Waste Storage Depot/ Transfer Station

(a) Sorting at the community bin (municipal bin)/ waste storage depot/ transfer station is not desirable. However, if source level sorting (as indicated in 8.10.2(a) and (b) above) is not developed, then such sorting may be allowed till a household-level sorting and collection system is established.

(b) Sorting at community bin/ waste storage depot/ transfer station can only be allowed to be carried out by ragpickers, if help of NGOs is taken and if ragpickers are given personal protective gear and proper implements and also if it is ensured that there is no scattering of waste.

8.10.4 Intermediate Sorting at Central Sorting Facility

A central sorting facility can be established if the cost of setting up and operating such a facility is met through the returns accruing from supply of recyclables to various vendors. In the present scenario, a central sorting facility at an intermediate stage is not visualised to be a viable option in India since the kabariwallahs and the ragpickers recover most of the valuable recyclables at the source. However, if such a facility is adopted, a semi-mechanised system with handpicking-off-the-belt would appear to be appropriate and economical for Indian condition in comparison to a fully mechanised system. The existing set of ragpickers would have to be integrated into such a system.

8.10.5 Sorting at Waste Processing Site

Pre-sorting at waste processing facilities is desirable to ensure that the processed output (such as compost) meets the regulatory standards. At small or decentralised waste processing facilities, receiving less than 25 tonnes per day of waste, manual pre-sorting is recommended prior to processing. For waste processing facilities receiving more than 25 tonnes per day of waste, semi-mechanised and mechanised pre-sorting is recommended. If a waste processing facility is receiving predominantly mixed waste in large quantities (in excess of 100 tonnes per day), the pre-sorting facility at such a site should be akin to a central sorting facility having semi-mechanised systems capable of sorting the mixed waste into various waste streams. Such a pre-sorting facility should have the following components : (a) conveyer belts for picking-off-the-belt; (b) screening devices for size separation; (c) magnetic separators and (d) shredders/ crushers for size reduction and (e) ballistics separators. The pre-sorting facility should be designed with adequate storage space as well as standby equipment to take care of system breakdowns.

At sites where pre-sorting is found to be operationally difficult, post-sorting can be adopted provided it is ensured that the end product meets all regulatory standards with respect to contaminants.

8.10.6 Sorting Prior to Landfilling

Sorting on landfill working face by ragpickers (i.e. behind the dozer) should be discouraged. It should only be permitted when the incoming waste rate is low (i.e. 2 to 3 trucks per hour at one working face). Protective gear for occupational injuries must be provided to all ragpickers. Since access to modern landfills is restricted, ragpickers must be allowed a prescribed entry and exit procedure. When the incoming waste volume is high, the chances of accidents are high and access to ragpickers is not recommended.

CHAPTER 9
STORAGE OF WASTE AT SOURCE

9.1. INTRODUCTION

Storage of waste at source is the first essential step of Solid Waste Management. Every household, shop and establishment generates solid waste on day to day basis. The waste should normally be stored at the source of waste generation till collected for its disposal. In India, such a habit has not been formed and in the absence of system of storage of waste at source, the waste is thrown on the streets, treating streets as receptacle of waste. If citizens show such apathy and keep on throwing waste on streets and expect that municipal sweepers should/would clean the city, the cities will never remain clean. Even if local bodies make arrangements to remove all the waste disposed of by the citizens on the street on day to day basis, the city will remain clean only for two to three hours and not beyond till the habit of throwing waste on the streets is not changed. There is, therefore, a need to educate the people to store waste at source, dispose of the waste as per the directions of the local bodies and effectively participate in the activities of the local bodies to keep the cities clean.

9.2. PRESENT SCENARIO

9.2.1. No Storage at Source

Generally no bins for storage of domestic, trade or institutional waste are kept at source. Very few people keep personal bins for storage of domestic, trade or institutional waste at source. The percentage of such people is insignificant. Under the situation most of the domestic waste as well as waste from shops, offices and establishments including hospitals, nursing homes, hotels, restaurants, construction and demolition wastes, etc., come on the streets or is disposed of unauthorisedly on public or private open plots or even discharged in the drains or water bodies nearby resulting in clogging of drains, pollution of water resources and increase in insanitary conditions in the urban areas.

9.2.2. Storage of Waste, Wherever Practised, does not Synchronize with Primary Collection System.

System of storage of waste at source, wherever practised, by and large, does not synchronize with the system of primary collection with the result the waste stored at homes, shops and establishments in domestic, trade or institutional bins also finds its way on the street resulting in unhygienic conditions on streets. Some types of receptacles presently used for storage are as under:

- Buckets
- Plastic bins
- Plastic bags
- Metal bins with or without lids

By and large such bins used are without lids. These are unsuitable for storage of food waste for 24 hours and more in the Indian conditions as waste starts stinking very fast due to putrefaction.

9.3. MEASURES TO IMPROVE THE SYSTEM

For keeping streets and public places clean through out the day, it is necessary that waste producers co-operate and effectively participate in the waste management efforts of local bodies. People, therefore, may be educated to form a habit of storing waste at source in their personal bin/bins and deposit such waste into the municipal system only, at specified times.

Urban local bodies must, therefore, take concerted measures to ensure that citizens do not throw any waste on the streets, footpaths, open spaces, drains or water bodies and instead store the waste at source of waste generation in two bins/bags, one for food waste/bio-degradable waste and another for recyclable waste such as papers, plastic, metal, glass, rags etc.(as under):-

9.3.1 Types of Wastes to be put in the Bin Meant for Food Wastes & Bio-degradable Wastes

- Food wastes of all kinds, cooked and uncooked, including eggshells, bones
- Flower and fruit wastes including juice peels and house-plant wastes
- House sweepings (not garden sweepings or yard waste: dispose on-site)
- Household Inert (sweepings/ashes)

9.3.2 Types of Recyclable and Other Non-Bio-degradable Wastes to be Kept Separately

- Paper and plastic, all kinds
- Cardboard and cartons
- Containers of all kinds excluding those containing hazardous materials
- Packaging of all kinds
- Glass, all kinds
- Metals, all kinds
- Rags, rubber, wood
- Foils, wrappings, pouches, sachets and tetrapaks (rinsed)
- Cassettes, computer diskettes, printer cartridges and electronic parts
- Discarded clothing, furniture and equipment

Wastes such as used batteries, containers for chemicals and pesticides, discarded medicines and other toxic or hazardous household waste (as under), if and when produced, should be kept separately from the above two streams of waste.

9.3.3 List of Some Domestic Hazardous Wastes

(A)

- Aerosol cans
- Batteries from flashlights and button cells
- Bleaches and household kitchen and drain cleaning agents
- Car batteries, oil filters and car care products and consumables
- Chemicals and solvents and their empty containers
- Cosmetic items, chemical-based
- Insecticides and their empty containers
- Light bulbs, tube-lights and compact fluorescent lamps (CFL)
- Paints, oils, lubricants, glues, thinners, and their empty containers
- Pesticides and herbicides and their empty containers
- Photographic chemicals

- Styrofoam and soft foam packaging from new equipment
- Thermometers
- Mercury-containing products

(B)

- Injection needles and syringes after destroying them both
- Discarded Medicines
- Sanitary towels,
- Disposable diapers and
- Incontinence pads (duly packed in polythene bags before disposal)

9.4. STEPS TO BE TAKEN BY URBAN LOCAL BODIES

9.4.1 For Storing Household Waste

All households may be directed that

- They shall not throw any solid waste in their neighbourhood, on the street, open spaces, and vacant plots or into drains.

- They shall (a) keep the food waste / bio-degradable as and when generated, in any type of domestic waste container, preferably with a cover, and (b) keep dry / recyclables wastes preferably in bags or sacks as shown in Fig. 9.1 and 9.2

- Use of a non-corrosive container with lid is advised for the storage of food/biodegradable/wet waste. A container of 15 litre (0.015 cu.mtr) capacity for a family of 5 members would ordinarily be adequate. However, a household may keep larger containers or more than one container to store the waste produced in 24 hours having a spare capacity of 100% to meet unforeseen delay in clearance or unforeseen extra loads. Wet wastes should preferably not be disposed of in plastic carry bags.

- Keep domestic hazardous waste listed under para 9.3 separately, for disposal at the place may be as arranged for by the ULB.

FIG. 9.1 DOMESTIC BIN USED FOR STORAGE OF FOOD / BIODEGRADABLE WASTE

FIG. 9.2 NYLON BAG UTILIZED FOR STORAGE OF RECYCLABLE WASTE AT THE HOUSEHOLD LEVEL THROUGH NGO EFFORT.

- A private society, association of flats/multistoried buildings etc. shall provide a **community bin** i.e. a bin large enough to hold the waste generated by the members of their society/association for storage of wet domestic wastes and instruct all residents to deposit their domestic waste in this community bin to facilitate collection of such waste by the local body from the designated spot.

- In case of Multi Storied buildings where it may be difficult for the waste collector to collect recyclable waste from the doorstep, the association of such buildings may optionally keep one more community bin for storage of recyclable material.

- In slums, where because of lack of access or due to narrow lanes, it is not found convenient to introduce house-to-house collection system, community bins of suitable sizes ranging from 40 to 100 litre (0.04 to 0.1 cu.mtr.) capacity may be placed at suitable locations by the local body to facilitate the storage of waste generated by them. They may be directed to put their waste into community bins before the hour of clearance each day as shown in Fig. 9.3.

FIG. 9.3 COMMUNITY BIN PLACED IN A SLUM POCKET FOR COMMUNITY LEVEL STORAGE OF DOMESTIC WASTE.

- In a situation where local bodies find it difficult to place smaller community bins in slums on account of lack of awareness among slum dwellers, the local bodies may provide larger containers which may match with the local body's transportation system at locations which may be suitable to slum dwellers and convenient for local bodies to collect such waste. Slum dwellers may be directed to deposit their waste in such larger bins before the hour of clearance of waste each day.

9.4.2 For Storing Waste from Shops/ Offices/ Institutions/ Workshops etc.

All shops and establishments may be directed that:-

- They shall refrain from throwing their solid waste/ sweepings etc. on the footpaths, streets, open spaces.

- They shall keep their waste on-site as and when generated in suitable containers until the time of doorstep collection.

- The size of the container should be adequate to hold the waste, they normally generate in 24 hours with 100% spare capacity to meet unforeseen delay in clearance or unanticipated extra loads.

- They shall keep hazardous waste listed under Para 9.3.3 separately as and when produced and disposed of as per directions given by the local ULB.

- The association of private commercial complexes/multi-storey buildings shall provide suitable liftable community bins which match with the waste collection and transportation system of the local body for the storage of waste by their members and direct them to transfer their waste into the community bin before the prescribed time on a day-to-day basis.

- The association should consult the local body in this matter in advance and finalise the type of bin and the location where such community bin/s shall be placed to facilitate easy collection of such waste.

Fig. 9.4 illustrates the use of such bins.

FIG. 9.4 ONE VARIETY OF BIN THAT COULD BE USED FOR COMMUNITY STORAGE OF WASTE IN MULTI-STOREY BUILDINGS/ COMMERCIAL COMPLEXES.

9.4.3 For Storing Waste from Hotels and Restaurants

All hotels and restaurants may be directed that

- They shall refrain from throwing their dry and wet solid waste/sweepings on the footpath, streets, open spaces or drains.
- They shall also refrain from disposal of their waste into municipal street bins or containers.
- They shall store their waste on-site in sturdy containers of not more than 100 Litre (0.1 cu.m)capacity. The container should have appropriate handle or handles on the top or side and rim at the bottom for ease of emptying.
- In case of large hotels and restaurants where it may not be convenient to store waste in 100 litre or smaller size containers, they may keep larger containers which match with the primary collection and transportation system that may be introduced in the city by the urban local body, to avoid double handling of waste.

- They may be directed to keep hazardous waste listed in para 9.3.3 separately as and when produced and dispose it of as per the directions of the urban local body.

9.4.4 For Storing Vegetable/Fruit Markets Waste

These markets produce large volumes of solid waste and local bodies may

- direct the association of the market to provide large size containers which match with the transportation system of the local body or
- depending on the size of the market, local body itself may provide large size containers with lid or skips as illustrated below for storage of market waste at suitable locations within markets on full cost/partial cost recovery as deemed appropriate.

Shopkeepers may be directed that they shall not dispose of waste in front of their shops/establishments or anywhere on the streets or in open spaces and instead shall deposit their waste as and when generated into the large size container that may be provided for storage of waste in the market as shown in Fig.9.5.

FIG. 9.5 LARGE CONTAINERS PLACED IN VEGETABLE / FRUIT MARKET ON A PAVED FLOOR FOR THE STORAGE OF MARKET WASTE.

9.4.5 Meat and Fish Markets

- The shopkeepers shall not throw any waste in front of their shops or on the streets or open spaces.
- They shall keep within their premises sturdy containers (of size not exceeding 100 litres i.e. 0.1 cu.m) having lid, handle on the top or on the sides and rim at the bottom of the container with adequate spare capacity to handle expected loads. However, slaughter house wastes should be handled as per the guidelines given in the chapter 5 on slaughterhouse waste.

9.4.6 Street Food Vendors

All street food vendors may be directed not to throw any waste on streets and pavements. They must keep bins or bags for storage of waste that they generate through their activity. Their handcarts must have a shelf or bag below for storage of waste generated in the course of business.

9.4.7 Marriage Halls/Kalyan Mandaps/Community Halls etc.

A lot of waste is generated when marriage or social functions are performed at these places and unhygienic conditions are created. Suitable containers with lids which may match with the primary collection or transportation system of local bodies should be provided by these establishments at their cost and the sites of their placement should be finalised in consultation with urban local bodies to facilitate easy collection of waste. On-site bio-digesters for food waste should be encouraged.

9.4.8 Hospitals/Nursing Homes/Pathological Laboratories/Health Care Centres/Establishments etc.

These establishments produce bio-medical as well as ordinary waste. These may be directed that

- they shall refrain from throwing any bio-medical waste on the streets or open spaces, as well as into municipal dust bins or domestic waste collection sites.
- They shall also refrain from throwing any ordinary solid waste on footpaths, streets or open spaces.
- They are required to store waste in colour-coded bins or bags as per the directions of the Govt. of India, Ministry of Environment Bio-medical

Waste (Management & Handling) Rules 1998, and follow the directions of Central Pollution Control Boards and State Pollution Control Boards from time to time for the storage of biomedical waste. The guidelines incorporated in the Chapter 7 on Biomedical waste may be followed.

9.4.9. Construction & Demolition Wastes

Directions may be given that:

- No person shall dispose of construction waste or debris on the streets, public spaces, footpaths or pavements.

- Till finally removed construction waste shall be stored only within the premises of buildings, or in containers where such facility of renting out containers is available. In exceptional cases where storage of construction waste within the premises is not possible, such waste producers shall take prior permission of the local authority or the State Government as may be applicable for temporary storage of such waste and having obtained and paid for such permission, may store such waste in such a way that it does not hamper the traffic, the waste does not get spread on the road and does not block surface drains or storm water drains.

- Local bodies above 10 lac population must make efforts to provide or encourage the facility of skips/containers on rent for storage and transportation of construction and demolition waste as illustrated in Fig.9.6.

To facilitate the collection of small quantities of construction and demolition waste generated in a city, suitable sites may be identified in various parts of the city and people notified to deposit small quantities of construction and demolition waste. Containers could be provided at such locations and small collection charge levied for receiving such waste at such sites and for its onward transportation. Rates may be prescribed for such collection by local bodies. Contracts could also be given for managing such sites.

For managing construction and demolition waste, the detailed guidelines given in the Chapter 4 on Construction and Demolition Waste may be followed.

FIG.9.6 CONTAINER KEPT FOR THE STORAGE OF CONSTRUCTION/ DEMOLITION WASTE

9.4.10 Garden Waste

Private gardens should as far as possible compost and re-use all plant wastes on-site. Where it is not possible to dispose of garden waste within the premises and the waste is required to be disposed of outside the premises, it shall be stored in large bags or bins on-site and transferred into a municipal system on a weekly basis on payment. The generation of such waste should as far as practicable be regulated in such a way that it is generated only a day prior to the date of collection of such waste. It should be stored in the premises and kept ready for handing over to the municipal authorities or the agency that may be assigned the work of collection of such waste.

Garden waste and fallen leaves from avenue trees within large public parks and gardens should be composted to the extent possible. However, if such waste has to be disposed of, large skips may be kept, which match with the municipal transportation system for transportation of such waste. Such skips may be provided by local bodies or State Governments owning such parks and gardens. In case of private parks and gardens they should make their own storage arrangement which matches with the municipal primary collection and transportation system.

9.5. STORAGE OF RECYCLABLE WASTE

It is essential to save the recyclable waste material from going to the waste processing and disposal sites and using up landfill space. Profitable use of such material could be made by salvaging it at source for recycling. This will save national resources and also save the cost and efforts to dispose of such wastes. This can be done by forming a habit of keeping recyclable waste material separate from food wastes, in a separate bag or a bin at the source of waste generation. This recyclable waste can be handed over to the waste collectors (rag pickers) at the doorstep.

9.6. MEASURES TO BE TAKEN BY THE LOCAL BODIES TOWARDS SEGREGATION OF RECYCLABLE WASTE

- Local bodies may mobilise voluntary organisations, Non-Governmental Organisations (NGOs) or co-operatives to take up the work of organising street rag-pickers and elevate them to door step "waste collectors" by motivating them to stop picking up soiled and contaminated solid waste from streets, bins or disposal sites and instead improve their lot by collecting recyclable clean materials from the doorstep at regular intervals of time. Local bodies may, considering the important role of rag pickers in reducing the waste and the cost of transportation of such waste, even consider extending financial help to NGOs and co-operatives in providing some tools and equipment to the rag pickers for efficient performance of their work in the informal sector.

- Local Bodies may actively associate resident associations, trade & Industry associations, Community Based Organisations (CBOs) and NGOs in creating awareness among the people to segregate recyclable material at source and hand it over to a designated waste collector identified by NGOs. The local body may give priority to the source segregation of recyclable wastes by shops and establishments and later concentrate on segregation at the household level.

- The upgraded rag pickers on becoming doorstep waste-collectors, may be given an identity card by the NGOs organising them so that they may have acceptability in society. The local body may notify such an arrangement made by the NGOs and advise the people to cooperate.

This arrangement could be made on "no payment on either side basis " or people may, negotiate payment to such waste collectors for the door step service provided to sustain their efforts.

9.7. PROVISION OF LITTERBINS ON STREETS, PUBLIC PLACES, ETC.

With a view to ensure that streets and public places are not littered with waste materials such as used cans, cartons of soft drinks, used bus tickets, wrappers of chocolates or empty cigarette cases and the like generated while on a move, litter bins may be provided on important streets, markets, public places, tourist spots, bus and railway stations, large commercial complexes, etc. at a distance ranging from 25 metres to 250 metres depending on the local condition. Similar bins for disposal of animal droppings could be placed in posh areas.

Some of the designs of such litterbins are shown in Fig.9.7.

FIG. 9.7 LITTERBIN PLACED IN A PUBLIC PARK

- Removal of waste from these litterbins should be done by beat sweepers during their street cleaning operations. Waste from the litterbins should be directly transferred into the handcarts of the sweepers.
- Such facilities of litterbins can be created at no cost to local bodies by involving the private sector and giving them advertisement rights on the bins for a specified period or by allowing them to put their names on the bins as a sponsor. Litterbins should be put in posh as well as poor areas in the proportion decided by local bodies.

9.8 PROVISION OF SPECIAL CONTAINERS FOR STORAGE OF DOMESTIC HAZARDOUS AND TOXIC WASTE

Urban local bodies should provide at strategic locations in different parts of the cities, specially designed containers having two compartments, one for domestic hazardous-toxic waste listed in 9.3.3(A) and another for those listed in 9.3.3.(B). A different colour scheme should be adopted for the containers placed for the storage of these domestic hazardous-toxic wastes. Citizens should be directed to deposit such wastes in such containers only as and when such waste is to be disposed of. Local bodies should insist that such wastes should not be mixed with organic or municipal general waste.

9.9 A statement showing the action to be taken by various categories of waste generators is as under:-

STORAGE OF WASTE AT SOURCE IN A NUTSHELL

	Source of Waste Generation	**Action to be taken.**
1.	Households	1. Not to throw any solid waste in the neighbourhood, on the streets, open spaces, and vacant lands, into the drains or water bodies. 2. Keep food waste/biodegradable waste in a non-corrosive container with a cover (lid) 3. Keep, dry/recyclable waste in a bin/bag or a sack. 4. Keep domestic hazardous waste if and when generated separately for disposal at specially notified locations.
2.	Multistoried buildings, commercial complexes, private societies, etc.	1 to 4 as above. 5. Provide separate community bin/bins large enough to hold food/biodegradable waste and recyclable waste generated in the building/society. 6. Direct the members of the association/ society to deposit their waste in community bin on day to day basis before the hour of clearance.
3.	Slums	1 to 4 as above. 5. Use community bins provided by local body for deposition of food and biodegradable waste.
4.	Shops, offices, institutions, etc.	1 to 4 as above. 5. If situated in a commercial complex, deposit the waste so stored as per 2 and 3 above in community bins provided by the association.

5.	Hotels & Restaurants	1 to 4 as above. However, the container used should be strong, not more than 100 litre in size, should have a handle on the top or handles on the sides and a rim at the bottom for easy handling.
6.	Vegetable & Fruit Markets	1. Provide large containers, which match with transportation system of the local body. 2. Shop keepers not to dispose of the waste in front of their shops or open spaces. 3. Deposit the waste as and when generated into the large container placed in the market.
7.	Meat & Fish Markets.	1. Not to throw any waste in front of their shops or open spaces around. 2. Keep a non-corrosive container/ containers not exceeding 100 litre capacity with lid handle and the rim at the bottom and deposit the waste in the said containers as and when generated. 3. Transfer the contents of this container into a large container provided by the association of the market or local body on day to day basis before the hour of clearance.
8.	Street Food Vendors	1. Not to throw any waste on the street, pavement or open spaces. 2. Keep bin or bag for the storage of waste that generates during street vending activity. 3. Preferably have an arrangement to affix the bin or bag with the hand-cart used for vending.
9.	Marriage Halls, Community Halls, Kalyan Mandaps, etc.	1. Not to throw any solid waste in their neighbourhood, on the streets, open spaces, and vacant lands, into the drains or water bodies. 2. Provide a large container with lid which may match with the transportation system of the local body and deposit all the waste generated in the premises in such containers
10	Hospitals, Nursing Homes, etc.	1. Not to throw any solid waste in their neighbourhood, on the streets, open spaces, and vacant lands, into the drains or water bodies. 2. Not to dispose off the biomedical waste in the municipal dust bins or other waste collection or storage site meant for municipal solid waste. 3. Store the waste as per the directions contained in the Government of India, Ministry of Environment Biomedical Waste (Management & Handling) Rules 1998.

11	Construction & Demolition Waste	1. Not to deposit construction waste or debris on the streets, foot paths, pavements, open spaces, water bodies, etc. 2. Store the waste within the premises or with permission of the authorities just outside the premises without obstructing the traffic preferably in a container if available through the local body or private contractors.
12	Garden Waste	1. Compost the waste within the garden, if possible. 2. Trim the garden waste once in a week on the days notified by the local body. 3. Store the waste into large bags or bins for handing over to the municipal authorities or contractors appointed for the purpose on the day of collection notified.

CHAPTER 10
PRIMARY COLLECTION OF WASTE

10.1. INTRODUCTION

Primary collection of waste is the second essential step of Solid Waste Management activity. Primary collection system is necessary to ensure that waste stored at source is collected regularly and it is not disposed of on the streets, drains, water bodies, etc. However, step has to synchronize well with the first step i.e. Storage of Waste at source.

10.2. PRESENT SCENARIO

In India, the system of primary collection of waste is practically non-existent, as the system of storage of waste at source is yet to be developed.

Doorstep collection of waste from households, shops and establishments is insignificant and wherever it is introduced through private sweepers or departmentally, the system does not synchronize further with the facility of Waste Storage Depots and Transportation of Waste. The waste so stored is deposited on the streets or on the ground outside the dustbin. Thus streets are generally treated as receptacles of waste and the primary collection of waste is done, by and large, through street sweeping.

An appropriate system of primary collection of waste is to be so designed by the urban local bodies that it synchronizes with storage of waste at source as well as waste storage depots facility ensuring that the waste once collected reaches the processing or disposal site through a containerized system.

10.3. MEASURES NECESSARY TO IMPROVE THE SERVICE

Local bodies should provide daily waste collection service to all households, shops and establishments for the collection of putrescible organic waste from the doorstep because of the hot climatic conditions in the country. This service must be regular and reliable. Recyclable material can be collected at longer regular intervals as may be convenient to the waste producer and the waste collector, as this waste does not normally decay and need not be collected daily. Domestic hazardous waste is produced occasionally. Such waste need not be collected from the doorstep. People could be advised or directed to deposit such waste in special bins kept in the city for disposal.

10.4. STEPS TO BE TAKEN

- Urban local bodies may arrange for the collection of domestic, trade and institutional food/ biodegradable waste from the doorstep or from the community bin on a daily basis.

- Local bodies may also arrange through NGOs collection of recyclable waste material/non bio-degradable waste other than toxic and hazardous waste from the source of waste generation at the frequency and in the manner, notified by local bodies from time to time in consultation with the NGOs/Resident Associations, etc.

- Domestic hazardous/ toxic waste material deposited by the waste producers in special bins (provided by the local body at various places in the city) may be collected at regular intervals after ascertaining the quantities of such waste deposited in special bins.

10.5. ARRANGEMENTS TO BE MADE FOR PRIMARY COLLECTION

Local bodies should arrange for the primary collection of waste stored at various sources of waste generation by any of the following methods or combination of more than one method:

- Doorstep collection of waste through containerized handcarts/tricycles or other similar means with active community participation as shown in the photograph in Fig. 10.1:

- Doorstep collection of waste through motorised vehicles having non-conventional/sounding horns deployed for doorstep waste collection with active community participation.

- Collection through community bins from private societies multi-storied buildings, commercial complexes,

- Doorstep or lane-wise collection of waste from authorised/unauthorised slums or collection from the community bins to be provided in the slums by local bodies [as illustrated in Figure 10.2(A)].

FIG. 10.1 DOORSTEP COLLECTION OF WASTE THROUGH CONTAINERIZED HANDCART WITH PUBLIC PARTICIPATION

FIG.10.2(A) PRIMARY COLLECTION THROUGH COMMUNITY BIN IN SLUMS

- House-to-house collection of waste from posh residential areas on full-cost-recovery basis where community participation is not to be done through NGO's efforts (as illustrated in Fig. 10.2 (B):

FIG. 10.2(B) HOUSE TO HOUSE COLLECTION OF FOOD/BIODEGRADABLE WASTE IN PRIVATE SOCIETY ON MONTHLY PAYMENT BASIS THROUGH PRIVATE SECTOR/NGO

10.6 TOOLS & EQUIPMENT

10.6.1 Hand Carts

The use of traditional hand carts should be discontinued and instead, hand carts having 4 to 6 detachable containers of capacity ranging from 30-40 litres i.e. 0.03 to 0.04 cu.m each should be used as shown in Fig.10.3. The containers should be of sturdy material preferably strong polyethylene/plastic with a handle on the top and rim at the bottom for easy handling of the container. The handcarts should have preferably three wheels and sealed ball bearing. There should be locking arrangement with a chain and a lock. The design and specifications of the handcart and the containers could be as shown in the Annexure 10.1.

FIG. 10.3 CONTAINERIZED HANDCART WITH 6 DETACHABLE CONTAINERS

10.6.2 Tricycles

Local bodies can use tri-cycles instead of handcarts in the areas which are spread out, and distances are long. The tricycles could have eight containers of 0.04 cu.m. (40 litres) capacity each as shown in Fig. 10.4 These containers should also be detachable from the tricycle and should have a locking arrangement.

FIG. 10.4 TRICYCLES HAVING 8 CONTAINERS FOR PRIMARY COLLECTION

10.6.3 Community Bin Carrier

A community bin carrier having a capacity to carry 40 containers (bins) in a two tier arrangement may be used to pick up community bins from residential areas and slums in the cities and towns where direct transfer of waste into the hand carts or tricycles is not found suitable. These vehicles with two member crew should pick up filled community bins and replace empty ones and take the vehicle, when 40 filled containers are picked up, to the nearest temporary waste storage depot (large container for transfer of waste) as illustrated in Fig. 10.5

FIG.10.5 USE OF COMMUNITY BIN CARRIER

10.7. METHODS OF PRIMARY COLLECTION OF WASTE

10.7.1 Door Step Collection through Containerized Handcarts

A bell may be affixed to the handcart given to the sweeper or a whistle may be provided to the sweeper in lieu of a bell. Each sweeper may be given a fixed area or beat for sweeping plus a fixed number or stretch of houses for collection of waste. The local bodies may, based on local conditions, fix the work norms as they deem appropriate. It is suggested that in congested or thickly populated areas, 250 to 350 running metres (RMT) of road length and the adjoining houses may be given to each sweeper, whereas in less congested areas 400 to 600 running metres of the road length with adjoining houses may be allotted to a sweeper depending upon the density of population in the given area and local conditions. In low-density areas even 650 to 750 running metres of road length and houses can be given. Normally 150 to 250 houses coupled with the above road length may be taken as a yardstick for allotment of work to an individual sweeper.

10.7.2 Role of Sweeper

The sweeper should ring the bell or blow the whistle indicating his arrival at the place of his work and start sweeping the street. The people may be directed through adequate publicity campaign that on hearing the bell or whistle they should deposit their domestic biodegradable waste into the handcart of the sweeper or hand over the waste to him/her.

At places where it is not convenient for the householder to deposit the waste in the handcart/tricycle, on account of their non-availability at home when sweeper arrives in their areas, they may leave the domestic waste in domestic bins or bags just outside their houses on the street in the morning so as to enable the sweepers to pick up the waste and put it into the handcart.

No sweeper may be expected or directed to do house-to-house collection by asking for waste at the doorsteps, as this will affect his energy and productivity.

10.7.3 Collection through Motorised Vehicles

Local bodies as an alternative to doorstep collection through containerised handcarts may deploy motorised vehicles having unconventional/sounding horn for doorstep collection of waste. Driver of the vehicle should intermittently blow the horn announcing his arrival in different residential localities and on hearing this, the householders should deposit their domestic waste directly into such vehicle without loss of time.

10.7.4 Primary Collection of Waste from Societies/Complexes

In private societies, complexes and multi storied buildings, normally no sweepers are provided by local bodies, hence private sweepers are generally engaged. It may therefore be made compulsory for the management of the societies, complexes and multi-storeyed builders, to keep community bins or containers in which dry and wet waste may be separately stored by there residents. Such bins may be placed at easily approachable locations to facilitate convenient collection by the municipal staff or the contractors engaged by the local body. The local body should arrange to collect waste from these community bins/containers through handcarts, tricycles, pick-up vans, or other waste collection vehicles as may be convenient, on a daily basis.

To facilitate collection of waste from societies or commercial complexes, the local bodies should by a rule, make it obligatory for them to identify an appropriate site within their premises for keeping such bin/container for the storage of waste.

10.7.5 Collection of Waste from Slums

Local bodies should collect waste from slums by bell ringing/whistle system along their main access-lanes. Residents should bring their wastes from their houses to hand carts. Where slum residents prefer community bins, they should bring their biodegradable waste to these bins only an hour or two before the time of clearance. The local body may, if so desired, engage a private contractor for collection of such waste. Performance certification by a “Mohalla (local level) Committee” may be insisted upon in such cases.

10.7.6 Collection-at-the Doorstep in Posh Residential Areas

In posh residential areas where the residents as a whole might not be willing to bring their waste to the municipal handcart/ tricycle, system of collection from the-door step on full cost recovery basis may be introduced. This service can be contracted out by the local body or NGOs or contractors registered with the local body may be encouraged to provide such service in the areas where it is found economically viable to introduce door to door waste collection service. This service may not be provided to isolated houses, shops and establishments. Penal provisions may be introduced for failure of service where contracts are proposed to be awarded.

10.7.7 Collection of Duly Segregated Recyclable/Non-io-degradable Waste from Households

Recyclable waste has a value. Several rag pickers in the urban areas, therefore, move from street to street, bin to bin and go to the dump yard to pick up recyclable waste. These rag pickers are exposed to health risks as they put their bare hands in contaminated waste. They sell contaminated waste to the waste purchasers stored in slums creating unhygienic conditions. Quite often they spread the waste at the dust bin site to pick up recyclable. This system can be improved by introducing a system of collecting recyclable waste from the doorsteps changing the roll of rag pickers to that of waste collectors. This informal sector could thus be organised through NGOs, upgraded and given an opportunity to earn their living through doorstep collection of unsoiled recyclable waste.

NGOs may be activated to organise the rag pickers and convert them into door-step waste-collectors to improve their quality of life and to reduce their health risk. This will also increase their income levels. NGOs may allot to such waste collectors specified lanes and by-lanes comprising of 150 to 250 houses and some shops for doorstep collection of recyclable. They may also be given identity cards by the NGOs for increasing their acceptability in society. NGOs and/or the corporation may support such waste collectors by giving them bags and tools required for collection of recyclable waste from the doorsteps. The local body may also inform the community of the arrangements made by the NGO and advise them to avail of the services as illustrated in the Fig. 10.6.

FIG. 10.6 HOUSE TO HOUSE COLLECTION OF RECYCLABLE WASTE THROUGH A WASTE COLLECTOR (UPGRADED RAGPICKER) – AN NGO EFFORT.

10.8 ENCOURAGEMENT TO NGO'S / PRIVATE SECTOR

Local bodies may also encourage NGO/private sector to collect both food/biodegradable waste as well as recyclable waste from the door steps on their own by making direct contractual arrangement with the residents' associations/commercial complexes to reduce their financial burden.

10.9 COLLECTION OF WASTE FROM SHOPS AND ESTABLISHMENTS

Shops and establishments normally open after 9 am. These timings do not synchronize with the usual work schedule of sweepers. Under such a situation one of the following alternatives may be adopted.

- Sweepers may first carry out the work of street sweeping in the morning hours as usual and soon thereafter take up the work of door-step collection of waste, after most of the shops have opened.

- Waste collectors (rag pickers) may be organised to collect the recyclable waste from shops and establishments as soon as they open, as most of such waste is recyclable. Working arrangements may be made with the shops and establishments accordingly. The shops & establishments may be asked to store waste in two bins if they produce waste other than recyclable waste also. This arrangement may be made on 'No payment' basis on either side.

- The recyclable material received by the waste collectors directly from shops and establishments would give them a better return. The waste would be dry and not soiled and would fetch a good price in the market. This will work as an incentive for them to continue door to door collection.

  The associations of markets, shops and establishments may be persuaded to organise this service with the help of NGOs and waste collectors in their market.

Note of caution:

Rag picking is an informal income-generating activity undertaken by a poor strata of society. The suggestion to improve their lot by upgrading them to the level of doorstep waste-collector is only with a view to improve the quality of life of the rag-pickers, relieve them from the dirty work of picking up soiled and contaminated waste to earn their living, integrate them in the mainstream of society by giving them access to the houses, shops and establishments to collect recyclable waste from the door step in the same informal manner. The rag-pickers should not, therefore, be given any formal employment on a daily or monthly wage by local bodies or even by NGOs as it may attract the provisions of labour laws. The NGOs should only help in improving their lot by organising them and need not play a role of their employers for the primary collection of recyclable waste from the doorstep. At the same time they should not be prevented by law from engaging in this occupation.

- Doorstep collection service from shops and establishment may be provided or may be contracted out on 'full cost-recovery' basis.

- Large commercial complexes could use 3.0 cu.m to 7.0 cu.m containers, which are commonly used by the local bodies for community storage of waste so that its transportation could be synchronized by local bodies along with other containers, kept in the city.

10.10. COLLECTION OF BIO-MEDICAL WASTE

Collection of bio-medical waste should be done in accordance with the rules/directions contained in the Ministry of Environment & Forests, Govt. of India Notification dated 20th July 1998 as the liability for safe disposal of bio-medical waste is on such waste producer and the local body as such is not directly responsible to provide any service. The recommendations given in the chapter on biomedical waste (Chapter 7) in the manual may be followed.

10.11. COLLECTION OF HOTEL AND RESTAURANT WASTE

Hotels and restaurants may make their own arrangements for collection of waste through their own association, or local bodies may extend help in primary collection of such waste by deploying their own manpower and machinery for door step collection of such waste on full-cost-recovery basis. The cost could be recovered on pro-rata basis. Doorstep service may be contracted out by local bodies if so desired.

Charges for the collection of hotel waste may depend upon the quantity of waste to be picked up from the hotels and restaurants and frequency of collection required.

The cost recovery may be planned according to the classification of hotels/ restaurants made on the above basis and decided in consultation with them.

Thorough survey of the waste generation by hotels/ restaurants may be made before the collection rates are introduced and notified.

10.12 VEGETABLE, FRUIT, MEAT AND FISH MARKETS WASTE

Such wastes should be removed on a daily basis either departmentally or through contractors on full or part-cost-recovery basis as may be deemed appropriate by local bodies.

Large containers kept in the fruit and vegetable markets should be removed during night time or non-peak hours and the waste from meat and fish markets should be collected through closed pick-up vans service by engaging a contractor, or departmentally as deemed expedient by the local body.

10.13 COLLECTION OF GARDEN WASTE

The waste stored in public and private parks, gardens, lawn plots etc. should be collected on a weekly basis by arranging a rotation for collecting such waste from different areas, on different days to be notified to the people to enable them to trim the trees and lawns accordingly and keep the waste ready. This waste may be got collected through a contractor or departmentally as deemed appropriate by the urban local authorities. Cost recovery may be insisted upon, based on the volume of waste collected.

10.14 COLLECTION OF WASTE FROM MARRIAGE HALLS, KALYAN MANDAPS, COMMUNITY HALLS, ETC.

The special arrangement should be made for collection of waste from marriage halls, kalyan mandaps, community halls, etc. daily on a full-cost-recovery basis. The cost of such collection could be built into the charges for utilising such halls. This service may be provided preferably through a contractor or departmentally as the local bodies deem fit. On-site, processing of food wastes by bio-methanation and composting may be encouraged.

10.15. COLLECTION OF CONSTRUCTION AND DEMOLITION WASTE

- Local bodies should prescribe the rate per tonne for the collection, transportation and disposal of construction waste and debris and notify the same to the people.
- Every person who is likely to produce construction waste may be required to deposit with the concerned local body an approximate amount in advance at the rates as may be prescribed by the local body from time to time, for the removal and disposal of construction waste from his premises by the local body. Such amount may be deposited at the time when the building permission is being sought and in cases where such permission is not required, at any time before such waste is produced.
- The charges for removal of construction waste to be doubled for those who fail to deposit the amount in advance.
- Large local bodies may provide skips (large containers) to the waste producers on rent for the storage of construction waste so that double handling of the waste can be avoided or use front end loader & trucks to pick up such waste. In small towns this may be done manually using trucks, tractors and manpower.

- To facilitate disposal of small quantities of construction/demolition waste, large containers may be placed in various parts of the city where waste producers may deposit small quantities through private labourers, cart pullers, donkeys, etc. and such waste may be collected by ULBs from time to time before such containers start over flowing.

10.16. DAIRY AND CATTLE-SHED WASTE

The dairies and cattle breeders having sheds within the city limits should be asked to move the cattle sheds outside the city limits and until this is implemented they should be directed not to stack the cow dung, grass or other stable wastes within their premises or on the roadside. They must transfer the waste produced by them daily into the specified municipal storage containers nearby, which should be collected at regular intervals by local bodies.

10.17 COLLECTION OF DOMESTIC HAZARDOUS & TOXIC WASTE

Collection of Domestic Hazardous & Toxic Waste such as used batteries, paints, broken tube lights, expired medicines and others shown in chapter of Storage of Waste kept separately in the bins placed in various parts of the city should be collected periodically by the urban local bodies and got segregated and disposed of as per the hazardous waste management rules of the Government of India.

ANNEXURE – 10.1

SPECIFICATION OF NEW DESIGN HAND WHEEL BARROW

S.No.	Material	Size	Details for	No.	Quantity	Remarks
1	M.S. Angle	25x25x5 mm	Top Frame	-	332 CM	
2	M.S. Angle	25x25x5 mm	Bottom Frame	-	330 CM	
3	M.S. Angle	25x25x5 mm	Standing support	4	100 CM	
4	M.S. Angle	25x25x5 mm	Bottom frame Section angle	1+2	230 CM	
5	M.S. Tee	40x40x6 mm	Bending wheel	2	314 CM	Each wheel
6	M.S. Flat	40x6 mm	Support wheel & hub	12	240 CM	Dia 500 each
7	M.S. Flat	20x5 mm	For axle bracke	2	70 CM	Wheel need
8	M.S. Flat	20x5 mm	Barrow Section Flat	-	710 CM	6 supports
9	MS Square bar	25x25 mm	Axle	1	100 CM	
10	Round head rivet	32x10 mm	Riveting	2 wheels	12 No.	
11	Round head rivet	25x8 mm	Riveting	2 wheels	12 No.	
12	Hexagonal bolt	40x10 mm	Axle & Bracket	2 side	4 Nos	
13	M.S. Washer	25x50 mm – 16G thick		2 side	4 Nos	
14	Cotter pin	6x50 mm length	TO joint	2 side	2 Nos	
15	C.I. Hub	Complete with axle hole 20 mm support hole 6 no. with turning etc. The weight of the hub 3.5 Kg	Each side	2 side	2 Nos	
16	HDPE Wheel	8”x3”x1” HDPE Wheel Red Colour	Front side of the Barrow	1	1 No.	HDPE Material
17	Bearing	SKF 6204 ZZ	For Wheels	2 sides	4 Nos	
18	Galvanise Tube	20 mm B grade	For handle	-	127 CM	
19	Black anti corrosive paint		Barrow should be painted coats inside & outside	With two		
20	MS bush	ID=25mm wall thickness- 3mm	For two sides of the wheel	2 sides	2 Nos	
21	M.S. Angle	25x25x5 mm	For handle	2 Nos	114 CM	

Note : Every Wheel Barrow should be equipped with 1500 mm long 5 MM MS chain and 7 Lever Jalaram lock. For each wheel barrow, MS chain should be provided with fitting arrangement.

SKETCH PLAN FOR REFUSE M.S. WHEEL BARROW

NOTE :- (1) ALL DIMENSIONS MENTIONED IN MILLIMETRES ONLY
(2) WHEEL BARROWS AS PER SAMPLE

POLYTHYLENE CONTAINER FOR WHEEL BARROW

SPECIFICATIONS FOR POLYETHYLENE CONTAINER TO BE USED IN THE HANDCART FOR COLLECTION OF SOLID WASTE

The polyethylene container having size of 325 mm x 325 mm at the top and 290 mm x 290 mm at bottom with overall height of 325 mm shall be designed for transferring solid waste to the communal waste storage sites.

Material of Manufacture

The material used for the manufacture of moulded polyethylene garbage bins should be virgin and the best quality. The material should conform to the following standards:

S.No.	Property	Testing Method	Unit	Value
1	Density	IS-7328-1992	Gm/cm^2	> 0.930
2	MFI	IS-2530-1963	GMs/10 min	1.5 to 5
3	Tensile strength	IS-8543-84 Part – 4/ Sec 7 1996	Kg/cm^2	120
4	Flexural modulus	IS-13360 part – 5/sec 7 1996	Kg/cm^2	3000
5	Hardness (Shore)	IS-13360 part-5/sec I 1992	D scale	> D 50
6	Vicat Softening Temp	IS-1336 part-6/sec I 1992	C	> 90
7	Impact Strength (2.5 Kg/1 mts)	IS-12701-1996	J/mm^2	No puncture or damage
8	Weathering – Colour fastness	IS-22530-1963		No.4 gray scale

Accelerated UV	ASTM-G-53	-	should be tested with Q>U>V type accelerated
Test (50^o C) Q.U.V.			Weather meter for 200 hours flexural modulus Should each be not less That 80% of the values Before exposure.

- The internal form and surface of the container shall be such that it will not trap the contents.

- There shall be no sharp edges anywhere on the container.

- The internal and external surfaces shall be smooth and non-porous, free from cracks, splits, dents, distortion, blisters, voids, air bubbles and other surface blemishes or defects.

- The bins are expected to be used in outdoor conditions. They should be UV stabilised and should be able to withstand outdoor weather conditions in India.

SPECIFICATIONS FOR POLYETHYLENE CONTAINER TO BE USED IN THE WHEEL BARROW FOR COLLECTION AND TRANSPORTATION OF SOLID WASTE

The polyethylene container having size of 325 mm x 325 mm at the top and 290 mm x 290 mm at bottom with overall height of 325 mm shall be designed for transferring solid waste to the communal waste storage sites. It shall be made from durable material. The moulded polyethylene container shall be made from one piece moulding process. It shall have top-rim outside and embossment as per requirement.

The bottom of container shall have 10 mm dia. of four holes. It shall be drilled at the corners. In-built suitable stiffner shall be provided in the bottom and 15 mm wide and 10 mm deep and suitable stiffner must be provided on both the sides other than the handle fixed sides. Built-rim shall be provided at bottom for easy handling and tilting container.

A handle shall be provided at the top of the container. The handle shall be made from 8 mm MS bar and both ends of handle shall be fitted at the top of container, with MS strips. The ends of handle shall be fitted with rivets by placing inside and outside MS strips. The fixing arrangement shall be such that it can hold handle firmly and easily so also tilting and lifting can be done.

TOLERANCES :- + or – 3 mm except wall thickness.

THICKNESS :- All side should be 3 mm thick.
Tolerances of +/- 5% will be allowed.
Bottom should be 4 mm thick.

CHAPTER 11
STREET CLEANSING

11.1 INTRODUCTION

The sweeping of streets is such a simple and humble occupation that it rarely attracts technical interest of the managers responsible for such activities. However, many cities spend between 30 to 50 percent of their solid waste budgets on street cleansing. It is a service for which a wide variety of tools, equipment and methods, both manual and mechanical, are available, and it is one in which there is often great scope for financial saving by the introduction of more efficient methods.

This is an area in which public relations are very important. Much of the work arises directly from shortcomings in public behaviour, such as throwing litter on the streets and open spaces. In some cities, however, a high proportion of street wastes arise from deficiencies in the refuse collection service as a result of which residents dispose of domestic and shop-wastes in the streets. The cost of removing wastes which have been scattered on the streets is very much higher than the cost of collecting similar wastes which have been placed in containers such as domestic wastes bins or litter containers.

Thus street cleansing policies should have the following objectives:

- the provision of services for the collection of wastes from source, i.e., efficient refuse collection,
- reduction of street litter by public education and awareness,
- the use of systems which achieve high labour productivity,
- the design and use of effective tools and equipment.

11.2 SOURCES

For the purpose of solid waste management all street wastes fall into three main categories:

11.2.1 Natural Wastes

These include dust blown from unpaved areas, sometimes from within the city and sometimes from a great distance, and decaying vegetation such as fallen leaves, blossoms and seeds which originate from trees and plants in the city. Natural wastes cannot be avoided, but may be controlled by such measures as the careful selection of the types of tree planted in the city.

11.2.2 Road Traffic Wastes

Motor vehicles deposit oil, rubber and mud; in addition, there is sometimes accidental spillage of a vehicle's load. Animals drawing vehicles deposit excrement on the road surface. At large construction sites mud is often carried out by motor vehicles and deposited on adjacent roads; in wet weather this can cause danger to other traffic by skidding. Traffic wastes are largely unavoidable but some legislative control is possible in the cases of load spillage and construction sites.

11.2.3 Behavioural Wastes

The main source of wastes is litter thrown by pedestrians and house or shop-wastes swept or thrown out of private premises instead of being placed in the suitable container meant for the purpose. Human spittle and the excrement of domestic pets also fall into this category and together provide health risk, which arises from street wastes due to inhalation of dust contaminated by dried spittle and excrement.

Behavioural wastes are largely avoidable provided an efficient refuse collection service is in operation and litter bins are provided for the use of pedestrians. But success requires a continuing programme of **public education and awareness** backed up by **legislation** and rapidly **operating enforcement** procedures.

11.3 MANUAL CLEANSING OF STREET AND PUBLIC PLACES

A street normally comprises three distinct paved surfaces: a highway for motor traffic, and footway on both sides for pedestrians. The footways are slightly elevated and are separated from the highway by a kerb and channel. The channel is the lowest part of the road structure and serves as a drainage channel during rainfall; at regular intervals it is provided with outlets for the surface water to the main drainage system.

It is rarely necessary to sweep the surface of the highway because motor traffic creates a turbulence, which carries dust and litter away from the crown of the road and concentrates it in the channels at the sides. Thus, street sweeping usually has two components: footways and channels.

Footway wastes are mainly light litter and a little dust; in the channels the proportion of dust and heavy wastes is usually greater. Therefore, the tasks tend to be different. Footways are large areas with a low concentration of wastes; channels are narrow strips with a high concentration of wastes, which tend to be heavy.

Although these principles apply to most streets of a city, the amount of wastes generated varies in proportion to the level of human activity; thus the necessary frequency of sweeping can range from several times a day to once or twice a week.

11.3.1 Frequency of Street Cleansing

Daily sweeping of public streets is essential where there is habitation close by. Isolated pockets or roads with little or no habitation around do not require daily cleansing but at the same time they cannot be ignored. A schedule of street cleaning should be prepared, prioritizing the roads requiring daily cleansing and the ones which are need to be cleansed periodically.

The following measures may be taken to ensure regular sweeping of streets and public places:

11.3.1.1 Cleansing of Street on a daily basis including Sundays and Public Holidays

Cleansing of the public roads, streets, lanes, by-lanes should be done daily if there is habitation or commercial activity on one or both sides of the street. A list of such roads and streets together with their length and width should be prepared and a program for their daily cleaning should be worked out by the local body keeping in view the work norms (yardsticks) prescribed. Roads and streets with no cluster habitation which do not require daily cleaning may be put in a separate group and may be taken up for need-based cleaning on alternate days, twice a week, once a week or occasionally, as considered appropriate by the urban local body. Similarly a timetable should be prepared for cleaning of open public spaces daily or periodically to ensure that they do not become dump yards and remain clean.

(a) Working on Sundays:

The generation of waste is a continuous process. As waste is produced each day, collection, transportation and disposal of waste is required to be done daily. There can therefore be no holiday in street sweeping, primary collection, transportation, processing and disposal of waste. All local bodies should therefore re-organize their work schedule and ensure that the Sanitation Department functions on all days in the year irrespective of Sundays and public holidays. This does not mean that Sanitation Department staff shall have no weekly off or holidays. The sweepers and other staff engaged in collection, transportation and disposal of waste as well as supervision of sanitation services should be given their statutory weekly off by rotation instead of giving them off on Sunday, by dividing the staff into seven groups and each group getting a weekly off on one of the days of the week. Thus one-seventh of the staff should be enjoying their weekly off on each day of the week. This will necessitate staff consolidation or creation of additional posts to the extent of one-seventh of the total strength of the staff in the cities where no cleaning is presently done on Sundays.

Alternatively, the staff may be given two half days (afternoon) off in a week in lieu of one full day weekly off if the sweepers agree to such an arrangement. Here the sweepers may leave work after working for 4 hours on two days out of seven days of the week to make up their weekly off. Perhaps they may be happy to have two half holidays instead of one weekly off in a week as they will have more time for themselves and the family twice a week. However, since this has legal implications, such arrangements will have to be worked out by mutual consent.

This arrangement of giving two half days' leave in lieu of one full day weekly off, may be made applicable to street sweepers and drain cleaners and their supervisors only and not to the transportation workers or workers engaged in the disposal of waste as these activities have to continue for full shifts of the day. One-seventh additional staff may be engaged in these sections of the SWM department to make up the requirement of working on all the days, or overtime may be given as per the need to complete the day's work.

(b) Review of Holidays given to the staff working in essential services such as Collection, Transportation, Processing and Disposal of Waste:

The list of public holidays being given to staff engaged in essential services vis-a-vis general category staff should be reviewed by the local body. Normally the number of holidays given to essential services staff are less than half the number of holidays given to general category staff. After review, the local body may finalize the number of holidays to be given to the sweepers and other staff in SWM and thereafter may make necessary arrangements for the collection, transportation and disposal of waste on all public holidays by either suitably compensating existing workers for holiday or by creating additional mechanisms to carry out the work on public holidays. The staff can also be compensated by giving additional earned leave in lieu of a public holiday, or additional salary/allowance as deemed proper. This suggestion does not preclude continuance of existing arrangements, if any, made by the local body to provide SWM services on public holidays.

(c) Substitution of Sanitation Workers:

When any sanitation worker remains absent or proceeds on leave, alternate arrangements must be made to ensure that cleaning is done as usual. Badli workers or leave reserve could be used for this purpose. Any other satisfactory arrangements, which are currently in use for this purpose, may continue. Work must not suffer on account of absenteeism.

(d) Prevent open Burning of Waste by Sweepers and the Public:

All Urban Local Bodies should take measures to prevent burning of tree leaves and other waste by sweepers on the roadside and direct sweepers to take all waste to the communal waste storage bins/sites only. Action may be taken against the erring employees. Where open spaces are available nearby, the leaves could be rapid-composted and used locally as organic manure for roadside plantations.

11.4 CLASSIFICATION OF STREETS

For the effective planning of manual sweeping it is necessary to classify streets, or sections of streets, according to the required frequency of sweeping. The following **Table 11.1**, shows a typical method of classification with the frequency of sweepings.

Each city should determine its own frequency requirements and develop an appropriate classification system. Time studies should then be carried out for each class of street and the results of these will indicate the length of street that a man can sweep at the required frequency. For example, time studies may show that for Class A streets one man can be allocated between 250 and 300 metres, while for Class F the length may be as great as 1.0 km. In measuring work content, sub-classification may be necessary to take account of variation in wastes generation within a given class.

Table 11.1 : A Typical Classification of Streets and the Frequency of Sweeping

Class	Character of Street	Frequency of Sweeping
A	City centre shopping	Daily
B	Market areas	Daily
C	City centre and minor streets	Daily
D	Sub-urban shopping streets	Daily
E	Residential streets (high & low income)	Daily
F	Roads and streets having no households/establishments on either sides	Once a week
G	Sub-urban main streets	Twice a week
H	Open space	Occasionally, when required. (minimum once in a fortnight)

On the basis of this information a city can be divided into sweepers' beats which contain fairly uniform workloads, despite great differences in the lengths to be covered.

11.4.1 Sweeping Methods

In the normal sweeping situation of footway and channel there is an established work method for a single operator which has been designed to minimize unproductive walking:

1. Park receptacle (normally a handcart) at commencement of section to be swept.
2. Using wide broom, sweep wastes off footway into channel for a convenient distance, say 20-50 metres.
3. Sweep channel in reverse direction, ending at parked receptacle; make intermediate heaps if quantity so required; *do not sweep across drainage grids.*
4. Move receptacle up to next section to be swept, picking up heaps on the way.

11.4.2 Work-norms for Street Sweepers

Work-norms for street cleansing depends on various factors e.g. city size, types of residential, institutional and commercial areas, quality and quantity of refuse generated etc. Suggested work-norms have been given at **Para 19.6 in Chapter 19 on *"Institutional and Capacity Building Aspects"*.**

11.4.3 Working Hours

Different cities have adopted different working hours depending on local conditions and age-old traditions. It is desirable to start work as early as possible in the morning so that the city looks clean before the roads and streets get busy in the morning.

Normally the labour force is required to work for 8 hours and is given half an hours' recess. Considering the type of work, it is desirable to split the 8 hours of duty of sweepers into two spells, 4 to 5 hours in the morning and 3 to 4 hours in the afternoon and the work force should be fully utilized in both the spells of duties. Quite often the work force is utilized in a group in the afternoon hours, which is highly unproductive. Individual work needs to be allotted to each person in both spells to ensure full output and accountability. The local body may decide the duty hours on the above lines and the total hours of work to be taken from the sweepers, subject to government policy, court orders and union agreements.

11.5 EQUIPMENT USED FOR STREET SWEEPING

Use of appropriate tool play an important role in improving the efficiency of the work force. Presently most of the tools utilized by the sanitation workers are inefficient and outdated and need to be replaced by efficient tools and equipment. Traditionally the work force resists any change, even if it is for their good. Persuasion and awareness efforts will, therefore, be necessary to convince the workforce to adopt improved tools and equipment. Equipment used for manual street sweepings are; brooms, shovels, and containers. These are described in the following sections:

11.5.1 Brooms

Instead of using short handled brooms which require bending of the body while at work, causes fatigue to the workforce and causes back pain in the long run, the workforce may be advised to use long handled brooms, which will not require bending, reduce fatigue and increase their productivity. In cities where a broom allowance is given, or only broom sticks are provided to sweepers, they may be persuaded that long handled brooms may be used or made by them for street sweeping. While making such brooms, a metal blade which can scrape the material sticking on the street should be fixed on the top of the broom, or a separate metal scraper may be given to the sweepers, to remove sticky material from the street while sweeping.

There is no yardstick about the number of brooms to be given to sweepers per month. In some cities three brooms per month are given, whereas in other cities only one broom is given per quarter of a year. One long handled broom per month is considered to be adequate for street sweeping. The bamboo (long handle) to which the broom is attached need not be given once a month as it has a long life. The same bamboo should be reused while making the broom. The bamboo may be replaced as and when required. It could be once in six months or once a year depending upon the local conditions of the city.

Delhi Model Broom, as shown in Fig. 11.1 is being extensively used in large cities and towns. General specifications of Delhi model broom are:

Length of the broom	80-85 cm
Weight of the broom	1 kg
Binding material	20 gauge MS sheet ring having width of 1.5-2 cm
Handle of the broom	Bamboo of 135 cm length, 3-4 cm dia
Weight of the bamboo handle (approximately)	900 gm

The bamboo sticks should be free from ruts, insects and of good quality. The handle of the broom should be solid and smooth in texture and free from insects. The bamboo should have a pointed edge on one end for proper fixing with the broom.

11.5.2 Shovels

The function of the broom is to gather the street wastes into small heaps, which then have to be picked up completely, and placed in a receptacle. The conventional tool for this purpose is a large straight-blade shovel. However, when the wastes comprise large quantities of very light materials such as leaves, a shovel is ineffective because dried leaves fall of or are blown away during transfer. A good solution to this problem is to use a pair of flat boards, usually plywood, between which the wastes are retained by hand-pressure. A typical design of hand shovel with specification is given at Fig. 11.2.

11.5.3 Container for Transfer of Sweepings

Various types of containers are used by the sweepers engaged in street sweepings for facilitating easy transfer of street-sweepings from the streets into the handcarts. Containers, which are normally used, made up of Cane, Bamboo, Plastic, Low Density Plastic (LDP), Metal or Fibre Reinforced Plastic (FRP). While selecting a particular type of container, economic consideration must be given keeping in view the life of the container. A general description of alternative containers for sweepers is given in Table 11.2.

Table 11.2 : General Description of Alternative Containers for Sweepers

	Cane basket	Bamboo basket	Other material bin
Plan cross section shape	Circular	Circular	Square
Top dimension (diameter or side) (mm)	440	450	450
Bottom dimension (mm)	380	350	300
Height (mm)	360	350	500
Weight (kg)	4	1.5	4
Capacity (litres)	25-40	25-40	25-40

11.5.4 Vehicles and Transfer Facilities

The work of a sweeper falls into two main parts:

(i) sweeping, and transferring wastes to receptacle, and

(ii) transporting full receptacle to a transfer point where it can be emptied.

In terms of sweeping, while the first activity is productive, the second is unproductive because it represents loss of sweeping time. The aim, therefore, should be to reduce to the minimum the proportion of time spent on transport. This can be achieved in two ways:

(i) minimizing the distance over which the collected wastes have to be transported, and

(ii) providing the maximum size of receptacle for swept wastes.

Various activities involved in the first approach are described as under:

An essential feature of the organization for street sweeping is the provision of a transfer facility within reasonable distance of each beat. The ideal arrangement is for this to be located in the district depot where it is under continuous supervision. It can take many different forms, but it must not be a dump on the ground, which would be unhygienic and costly in manpower for re-loading. The following are systems in common use, and the capacities are based on 40 sweepers each of whom brings in 0.5 m^3/day, a total for the district of 20 m^3/day:

(i) a side-loaded trailer of 7 m^3, exchanged three times a day, and

(ii) a steel skip of 4 m^3 exchanged five times/day by a skiphoist vehicle.

There is an alternative to the provision of transfer facilities for sweepers: this is to arrange for every sweeper to be visited about four times a day by a vehicle into which his full bins are emptied. The system requires very careful routing and the observance of precise timetables by sweepers and vehicles to ensure rendezvous without tedious searches. It has the advantage that the sweeper is able to devote the whole of his time to sweeping, but it does not eliminate the need for the other depot facilities such as welfare and handcart parking.

The second one which has been seriously neglected in many cities and towns. Often sweepers are given baskets for the transport of street wastes, as a result of which they spend most of their day walking to empty the basket instead of sweeping. The best solution is a handcart, the gross weight of which may be as much as 50 to 60 kg in level areas and less in hilly areas.

The handcart design should avoid the need to empty the cart on to the ground at the transfer place, because this would create the unnecessary task of shovelling wastes into another vehicle at the time when the wastes is to be delivered to the disposal site. A better method is to equip the handcart with a number of portable receptacles that can be lifted off and emptied by one man into a transfer facility serving a number of sweepers.

The desirable features of a handcart for use by a single sweeper are as follows:

(i) frame of light tubular steel, or angle, supporting a platform on which are placed two or more portable bins,

(ii) wheels of large diameter, with rubber tyres, preferably pneumatic, ball or roller bearings,

(iii) the portable bins should have a capacity of 30-40 litres each, according to the density of the wastes,

(iv) brackets should be mounted on the frame of the handcart to carry three brooms and a shovel.

11.5.5 Hand-Carts/Tricycles

Each sweeper engaged in street sweeping should be given a handcart having 4 to 6 containers or a tricycle having 8 or more containers of 30 to 40 liters capacity each as illustrated below, for ease of handling. These containers should be detachable to facilitate the direct transfer of street sweepings and household waste from the container into the communal waste storage bins. Such containers should lockable with a chain arrangement. The handcart should have at least 3 wheels ball bearings so that it can be used efficiently. A typical sketch of six-bin handcart arrangement is shown in Fig. 11.3.

A detailed drawing of a new Handcart (M.S. Wheel Barrow) is shown in Fig. 11.4 and their specifications are given in Table 11.3.

A detailed sketch of Polyethylene Container to be used in the Handcart (M.S. Wheel Barrow) for collection and transportation is shown in Fig. 11.5.

Table 11.3 : Specification of New Design Hand Wheel Barrow

Sl. No.	Material	Size	Details for	No.	Quantity	Remarks
1.	M.S. Angle	25x25x5 mm	Top frame	-	332 cm	
2.	M.S. Angle	25x25x5 mm	Bottom frame	-	330 cm	
3.	M.S. Angle	25x25x5 mm	Standing support	4	100 cm	
4.	M.S. Angle	25x25x5 mm	Bottom frame Section angle	1+2	230 cm	
5.	M.S. Tec	40x40x6 mm	Bending wheel	2	314 cm	Each wheel
6.	M.S. Flat	40 x 6 mm	Support wheel & hub	12	240 cm	Dia 500 mm each
7.	M.S. Flat	20 x 5 mm	For axle bracket	2	70 cm	Wheel need
8.	M.S. Flat	20 x 5 mm	Barrow Section Flat	-	710 cm	6 supports
9.	M.S. Square bar	25 x 25 mm	Axle	1	100 cm	
10.	Round head rivet	32 x 10 mm	Riverting	2 wheels	12 No.	
11.	Round head rivet	25 x 8 mm	Riverting	2 wheels	12 No.	
12.	Hexagonal bolt	40 x 10 mm	Axle & Bracket	2 side	4 Nos.	
13.	M.S. Washer	25x50 mm-16G thick		2 side	4 Nos.	
14.	Cotter pin	6 x 50 mm length	TO joint	2 side	2 No.	
15.	C.I. Hub	Complete with axic hole 20 mm support hole 6 no. with turning etc. The weight of the hub 3.5 kg.	Each side.	2 side	2 No.	
16.	HDPE Wheel	8”x3”x1” HDPE Wheel Red colour	Front side of the Barrow	1	1 No.	HDPE Material
17.	Bearing	6204 ZZ	For wheels	2 sides	4 Nos.	Standard quality.
18.	Galvanise tube	20 mm B grade	For handle	-	127 cm	
19.	Black and corrosive paint		Barrow should be painted coats inside & outside.	With two		
20.	M.S. Bush	CD = 25 mm wall thickness-3 mm	For two sides of the wheel	2 sides	2 Nos.	
21.	M.S. Angle	25x25x5 mm	For handle	2 Nos.	114 cm	

Note: **Every wheel barrow should be equipped with 1500 mm long 5 mm MS chain and 7 Lever Jalaram lock. For each wheel barrows MS chain should be provided with fitting arrangement.**

11.5.5.1 Specifications for Polyethylene Container to be used in the Handcart (M.S. Wheel Barrow) for Collection and Transportation of Solid Waste

The polyethylene container having size of 325 mm X 325 mm at the top and 290 mm X 290 mm at bottom with overall height of 325 mm shall be designed for transferring solid waste to the communal waste storage sites. It shall be made from durable material. The moulded polyethylene container shall be made from one piece moulding process. It shall have top-rim outside and embossment as per requirement.

The bottom of container shall have four holes of 10 mm dia. It shall be drilled at the corners. Inbuilt suitable stiffener shall be provided in the bottom and 15 mm wide and 10 mm deep and suitable stiffener must be provided on both the side other than the handle fixed sides. Built-rim shall be provided at bottom for easy handling and tilting container.

A handle shall be provided at top of container. The handle shall be made from 8 mm MS bar and both ends of handle shall be fitted with rivets by placing inside and outside MS strips. The fixing arrangement shall be such that it can hold handle firmly and easily so also tilting and lifting can be done.

TOLERANCES:	1 or – 3 mm except wall thickness
THICKNESS:	All side should be 3 mm thick. Tolerances of +/ - 5% will be allowed. Bottom should be 4 mm thick.

11.5.5.2 Material of Manufacture

The material for the manufacture of moulded polyethylene garbage bins should be virgin and of the best quality. The material should also conform to the standards as indicated in Table 11.4.

11.6 CLEANSING OF SURFACE DRAINS

In many cities there are open surface drains beside the road, into which quite often the sweepers and the public dispose of waste unauthorisedly. These drains need to be cleaned on a regular basis to permit free flow of waste water. Action should be taken to ensure that sweepers and citizens do not dispose of any waste into drains.

Table 11.4 : Properties and Standards of the Material

Sl.No.	Property	Testing method	Unit	Value
1.	Density	IS-7328-1992	Gm/cm^2	> 0.930
2.	Melt Flow Index	IS-2540-19631	GMs/10 min	1.5 to 5
3.	Tensile strength	IS-8543-84 part-4/sec 7 1996	Kg/cm^2	120
4.	Flexural modulus	IS-13360 part-5/sec 7 1996	Kg/cm^2	3000
5.	Hardness (shore)	IS-13360 part-5/sec 1 1992	D scale	> D 50
6.	Vicat Softening Temp	IS-1336 part-6/sec 1 1992	C	> 90
7.	Impact strength (2.5 kg/1 mts)	IS-12701-1996	J/mm^2	No puncture or damage
8.	Weathering - Colour fastness	IS-22530-1963	-	No. 4 gray scale

- Accelerated Ultra Violet Test (Q.U.V.) - ASTM-G-53, (50^{o}C) - should be tested with Q.U.V test type accelerated weathero-meter for 200 hours. Tensile strength and flexural modulus should each be not less than 70% of the values before exposure.

- **The internal form and surface of the container shall be such that it will not trap the contents.**
- **There shall be no sharp edges anywhere on the container**
- **The internal and external surfaces shall be smooth and non porous, free from cracks, splits, dents, distortion, blisters, voids, air bubbles and other surface blemishes or defects.**
- **The bins are expected to be used in outdoor conditions. They should be UV stabilized and should be able to withstand outdoor weather conditions in India.**

Initially, drain cleaners reporting to the Solid Waste Management Department should be given the work of cleaning shallow surface drains (not more than 60 cms) upto 500 meter length per day and this length may be increased as soon as the discharge of solid waste into the drain is substantially reduced.

Necessary tools should be given to the drain cleaners. They should also be given suitable seamless handcarts and shovels for transferring the silt to sites identified for depositing it. The periodicity of cleaning such drains should be worked out based on the conditions and frequency of clogging of drains. The Roster of Cleaning of such drains should be worked out and strictly followed.

Whatever waste is removed from the drains should not be allowed to remain outside the drain for long for drying. It would be desirable to deposit the wet silt into a seamless handcart as soon as it is taken out from the drain. If that be not possible or found difficult, the silt may be allowed to dry for about 4 hours outside the drain before transporting the semi-solid silt for disposal.

In special situations a maximum of 24 hours should be allowed for removal of such waste. Seamless handcarts may be used for transfer of silt from the surface drain site to the waste storage depot. Shovels should be used for transferring the contents from the seamless handcart or tricycle to a larger container kept at the temporary storage depot or communal waste storage site.

If this work can be contracted out the contractor should ensure that the silt removed from the drain is similarly lifted promptly and taken to the disposal site as per the terms of contact.

11.7 REMOVAL OF SILT FROM UNDERGROUND DRAINS/ MANHOLES

The work of removal of silt from underground drains or manholes, storm water drains or surface drains deeper than 600 mm, should be done by the Engineering Division of the local body and this work should not be entrusted to the SWM department. The silt so removed should not be kept on the road/footpath for drying. This waste should be removed on the same line as suggested for silt removed from the surface drains. Wet waste only be removed immediately from the main roads and not less than in 4 hours and in other areas within 24 hours and taken to the disposal site to prevent nuisance and health hazards. This waste should not be taken to the compost plant, but may be used as landfill cover.

11.8 MECHANICAL SWEEPING

Most mechanical sweepers are suction machines, usually assisted by one or more revolving "scarifying" brushes for dislodging adhering matter. They range in size from small pedestrian-controlled pavement sweepers to large channel sweepers, which often have an auxiliary engine to provide suction. The smallest machines operate at about 3 kmph, the largest at 8 kmph or faster. Some of the latter can be fitted with a wander-hose which can be controlled by an attendant and used to pick up refuse from inaccessible places; for example dry leaves from a drainage ditch.

Pavement sweepers are not usually practicable for cleaning normal footways because of obstructions such as lamp-columns, and the presence of pedestrians. Their main application is for very large paved areas such as central reservations and car parks. When they can be deployed effectively, they are very efficient for the removal of fine dust.

Channel sweepers have the same virtue, but they also have serious limitations, in particular:

(i) no car parking can be allowed on mechanical sweeper routes,

(ii) well-engineered roads are essential, particularly channel and kerb alignment,

(iii) the serviceability of mechanical sweepers is low compared with most other vehicles,

(iv) they are subject to damage by heavy objects lying on the road, or during travel over rough ground at disposal sites.

One function for which channel sweepers are supreme is the cleansing of heavy traffic roads on which the employment of manual sweepers may be dangerous. For this purpose, and also for one-way streets, the machine must be capable of working in either the left or the right-hand channel.

11.9 INSTITUTIONAL ARRANGEMENT FOR MANUAL SWEEPERS

For the effective management of sweepers, and for the transfer of their collected wastes, depots are required with the following facilities:

(i) office for the district supervisor, where sweepers book on and off,

(ii) parking area for handcarts with minor repairing facilities,

(iii) tool and equipment store,

(iv) transfer facility for sweepings,

(v) toilet and welfare facilities.

Each depot should be located, as far as possible, at the centre of a sweeping district, the area of which will be determined by the number of sweepers and the lengths of their beats. In a city centre beats will be short and there may be more than 40 sweepers employed per square km; thus depots may be required on a grid of 1 km. In this case the average walking distance from beat to depot would be less than 500 metres. In a sub-urban residential area the number of sweepers per square km may be one or even less, and thus the depots would be more widely spaced. For example, a depot employing 20 sweepers may serve a district with an area of 25 km^2 equivalent to a grid of 5 km. In this case the average walking distance between depot and a beat could be 2 km and, therefore, the beats should be planned radially, to permit working on an outward and return basis each day.

11.10 LEGISLATION

Because of the behavioural origins of a large part of street wastes, legislation can often assist in achieving higher standards of cleanliness and reducing the total workload. Legislation on street cleansing has been incorporated in detail in **Chapter 24 on *"Legal Aspects"*.**

CHAPTER 12
WASTE STORAGE DEPOTS

12.1 INTRODUCTION

This is the third essential step for an appropriate Solid Waste Management System. All the waste collected through Primary Collection System, from the households, shops and establishments has to be taken to the processing or disposal site either directly necessitating a large fleet of vehicles and manpower or through cost effective systems which are designed to ensure that all the waste collected from the sources of waste generation is temporarily stored at a common place called "Waste Storage Depots" and then transported in bulk to the processing or disposal sites. Such temporary arrangement for storage of waste is popularly known as dust bin, Dhalavs,etc. This facility has to be so designed that the system synchronizes with the system of primary collection as well as transportation of waste.

12.2 THE PRESENT SCENARIO

In India, the system of providing waste storage depots is most inefficient, unhygienic and unscientific, posing a serious threat to the public health and environment. In most cities, waste storage depots are of the following types.

1. Open sites,
2. Cement-concrete-cylindrical bins,
3. Masonry bins,
4. Metal rings,
5. Dhalavs, etc.

At some places metallic containers are also placed. Deposition of waste at the open waste storage sites is most unscientific and unhygienic. The waste is just dumped at such sites from the wheel barrows/hand carts and waste remains littered around such sites causing insanitary conditions, foul smells, environmental pollution besides giving unsightly appearance till it is removed as could be seen from the photographs in Fig. 12.1. This waste also necessitates multiple handling till it is finally disposed off.

FIG. 12.1 OPEN WASTE STORAGE DEPOT

Similar is the position of cylindrical and masonry bins where waste overflows outside the bin as these are poorly designed and not user friendly. Sweepers do not put the waste in such bins and instead throw the waste outside the bin due to wrong design of the handcart and inappropriate size of the bin as shown in the photograph in Fig. 12.2. These bins necessitate multiple as well as manual handling of contaminated waste.

Large concrete bins or "dhalavs" are constructed at some places for bulk storage of waste. These designs are also unsuitable as sanitation workers do not take the waste inside but throw the waste at the entrance blocking the passage. Waste is thus seen more outside the bin than inside. Waste stored at such depots also necessitates multiple handling.

12.3. MEASURES TO IMPROVE THE SITUATION

The solid waste collected from the doorsteps or from the community bins through the primary collection system needs to be unloaded and stored at convenient places for its onward transportation in a cost-effective manner.

Temporary waste storage depots which synchronize with primary collection and transportation system are, therefore, required to be located at suitable sites in lieu of open waste storage sites, and in replacement of cylindrical cement bins, masonry bins, Dhalavs, etc.

FIG. 12.2 USE OF ILL-DESIGNED WASTE STORAGE DEPOTS

12.4 STEPS TO BE TAKEN BY THE LOCAL BODY

The local body, taking into consideration that there is adequate space to place one or more containers of 3 to 10 cu.m size, the proposed waste storage depot would not obstruct the entrance of any building, would not cause hindrance to the traffic, there is adequate space for the movement of vehicles which come to pick up the container, should identify suitable locations at a distance not exceeding 250 metres from the work place of sanitation workers where waste storage depots facilities can be created. As far as practicable, such depots should be created at the existing unhygienic waste storage depot sites to minimize the objections from the people. As soon as such sites are identified, the sites should be prepared in such a way that a large size closed body container/containers can be placed at the site and it becomes possible to bring waste up to such containers easily and transfer the contents from the hand carts. It should also be possible to remove the container or replace with the hydraulic vehicle without causing inconvenience to the people and obstruction to the traffic. Soon thereafter all open waste storage sites should be abolished expeditiously and all dust bins made of cement pipes, metal rings, masonry construction, Dhalavs, etc., should also be replaced in a phased manner by a neat mobile container placed at the site identified for deposition of waste through containerised hand carts/containerised tricycles etc., bringing waste from the door steps, from the community bins and from the streets.

12.5. OPTIONS FOR SELECTION OF CONTAINERS

There are variety of containers, which can be placed at the waste storage depots. The local body may consider one or more options stated below.

- Depending on the quantities of waste likely to be deposited at the temporary waste storage depots, provide one or more large metallic containers (3 to 10 cu.m) with lid as illustrated in Fig. 12.3 at the Waste Storage Depots.

- **Distance between the Depots**

Such depots should be at a distance not exceeding 250 meters from the place of work of the sweepers. The distance between two bins should, therefore, not exceed 500 meters. The distance between the bins can be determined on the basis of the load of garbage/refuse that is likely to be received at the container from the area concerned.

FIG. 12.3 CONTAINERS PLACED AT THE WASTE STORAGE DEPOTS

- **Flooring below the containers**

The bins should be placed on cement concrete or asphalt flooring having a gradual slope towards the road to keep the site clean as shown in the photograph at Fig.12.4 below. The design and specifications for construction of flooring for placing the containers may be seen kept at Annexure-12.1. Rectangular flooring should be done in such a way that the container is kept in the centre as shown in the photograph in Fig. 12.3 and there should be paved space left on both sides of the container to facilitate transfer of waste from the hand cart / tricycle into the container. The flooring should be flush with the border of the road to maintain hygienic conditions and facilitate early transfer of waste from the handcart/tricycle into the container. A catch pit may be provided close by, if storm water drains exist in the city.

FIG. 12.4 CEMENT CONCRETE FLOORING FOR PLACEMENT OF CONTAINER

- At places where due to narrow roads, it may be found difficult to place container as shown above. The container may be placed lengthwise to facilitate loading from the front side only. Transportation of container in such a situation may have to be done from the side of the road as shown in Fig. 12.5.

FIG. 12.5 CONTAINERS PLACED LENGTHWISE ON NARROW STREETS

- In areas where placement of large containers is inconvenient on account of congestion, narrow roads, etc., one or more small containers of 0.5 to 1.00 cu. m. size as illustrated in Fig. 12.6 may be placed on the roads, lanes and by lanes at short distances not exceeding 100 meters. These bins should also be kept on paved flooring as shown in option (1) and cleared daily.

FIG. 12.6 SMALL CONTAINER PLACED AT SHORT INTERVALS IN LIEU OF LARGE CONTAINER

- In highly congested areas where it is difficult to place containers or send out a vehicle to collect waste from such bins, the local body may press into service small waste collection vehicles for direct transfer of waste from the hand cart/tricycles into such vehicles. Such vehicles can be parked at suitable locations/junctions in the congested areas for a few hours in the morning where sweepers can bring the waste easily as can be seen from the photograph in Fig. 12.7.

FIG. 12.7 SMALL WASTE COLLECTION VEHICLES UTILIZED FOR DIRECT TRANSFER OF WASTE

- In small cities where the local body feels that it will be difficult to maintain hydraulic vehicles for transportation of such containers, it should place a low bed Tractor Trolley or containers., which could be towed away by a tractor or a similar prime mover at the temporary waste storage site. The flooring should be paved for placing such trolleys or containers and maintaining hygienic conditions.

12.6 CRITERIA FOR PLACING LARGE SIZE CONTAINERS AT THE WASTE STORAGE DEPOTS

As far as practicable large sized closed body containers may be placed at the temporary waste storage depot to minimise the cost of transportation. The density of Indian waste is generally 500 Kgs./ cu. m. So containers of 1 cu. m. volume would be required per 500 Kgs. of waste depending on the quantity of waste expected to be received at the waste storage depot each day. The container/containers of at least twice the capacity may be placed at such locations to prevent over flow of bins and have freedom to lift the bin at the local body's convenience. For instance, if at one location two towns of waste is expected, depending on the density of waste, a container of 4 cu. m. capacity is necessary to hold the waste. Two containers of 4.0 to 4.5 cu. m. may be placed at such locations so that there will be no over flow and the container when about to be full, can be lifted.

If the total quantity of waste to be transported in the city each day 100 tonnes i.e. 200 cu.m., the local body should place containers having a total capacity of at least 400 cu.m. This will create 100% spare capacity which will avoid the over flow and enable the local body to transport the containers in any shift or on the alternate day or even twice a week depending on when the container gets full.

Such containers can be made of various designs with a variety of specifications by private sector. What is important is that the container should have the designed capacity, good strength, the loading height less then one metre so that it may not be difficult for sweepers, particularly female sweepers to transfer the contents from the hand carts container into the large container. A typical design and specification for 7cu.metre container may be seen at Annexure-12.2. This design or specification may not be taken as a standard recommended design. It is just an example

12.7 MAINTENANCE OF WASTE STORAGE DEPOTS/CONTAINERS

A periodical inspection should be carried out once in three months of the waste storage depots and any damage caused to the flooring, screen walls, etc. should be repaired.

Waste storage container and hand cart which bring waste to the waste storage depot should be repaired expeditiously as soon as reported by sweepers and they should be given replacement against taking their hand carts / containers for repair so that the work does not hamper.

Large containers generally have a strong frame and the metal sheets of the container get corroded if not well maintained. Annual painting of the container from inside and outside must be carried out for increasing the life and better appearance of containers.

When the metal sheets of large containers give way, the entire container need not be replaced; only the sheet may be repaired or replaced. It is only when it is felt that its main frame has given way and repairing is not possible the entire container may be replaced. A large container should normally last 12 to 8 years.

Hand-carts generally last 4 to 5 years but containers may last only 1 to 2 years. Containers as and when worn out should be replaced maintaining adequate stock of the same in the work-shop or in the solid waste management departmental stores.

ANNEXURE-12.1

The specifications for construction of waste storage depot.

1. The waste storage depot shall be of 20 ft. x 20 ft., 30 ft. x 30 ft., 60 ft. x 30 ft. for placing one, two and three containers respectively.

2. The three sides of the waste storage depot should be of 6" thick RCC wall having 4 ft. height.

3. There shall be RCC flooring of 6 inch thickness.

4. The flooring height shall be 6 inches above the ground from the farthest end touching the screen wall and shall gradually taper down to the ground level.

5. An approach road should be made from the road to the waste storage depot for the hand carts to reach conveniently the container placed on the flooring of the depot.

SKETCH PLAN FOR RCC WASTE STORAGE SITE (30’ x 20’)

ANNEXURE – 12.2

GENERAL SPECIFICATIONS OF 7 CU.MT. CAPACITY GARBAGE CONTAINERS TO BE HANDLED BY 7 CU.MT. D.P. UNITS

1. Container should be of 7 CU.MT. volumetric capacity & should be strong enough to handle the garbage of its maximum capacity.

2. Container shall have its –
   - Bottom plate (i.e. floor of 5 MM thick MS plate
   - Sides, front & top portion of 3 MM thick MS sheet.
   - Rear door of 3 MM thick MS sheet.
   - 4 nos top lids/windows of 1.6 MM thick MS sheet having diagonal angle support inside the window for its sturdiness.

3. There should be minimum 4 nos. cross stiffner/cross members, along the length of the container with end to end. Cross member should be minimum of ISMC-75 size MS channel.

4. There must be 2 nos. longitudinal channels beneath the floor to strengthen the floor of minimum ISMC-75 size MS channel.

5. All the plate/sheet joints at container edge/border must be supported with continuous MS angle of minimum 40 x 40 x 6mm thick size.

6. Angle for rear door & top lid should be of 25 x 25x 3 mm.

7. Container outerside shall be coloured as per requirement.

8. - Internally coloured with black anti-corrosive epoxy paint.
   - Bottom of the container shall also be painted with black anti-corrosive colour.
   - Prior to painting 2 costs of primer/red oxide shall be applied as per the paint manufacturing standard.
   - Colour must be of first class quality of Nerolac/Asian/Berger/J&N or equivalent standard brand.

9. Local Body's logo shall be painted as per instructions.

10. First sample container should be got approved from the Local Body.

Suggestions/instructions given by the representative Local Body, shall be implemented during the inspection.

TOP VIEW

BOTTOM VIEW

SIDE VIEW OF GATE

SIDE VIEW

CHAPTER 13
TRANSPORTATION OF WASTE

13.1. INTRODUCTION

Transportation of the waste stored at waste storage depots at regular intervals is essential to ensure that no garbage bins/containers overflow and waste is not seen littered on streets. Hygienic conditions can be maintained in cities/towns only if regular clearance of waste from temporary waste storage depots (bins) is ensured.

Transportation system has to be so designed that it is efficient, yet cost effective. The system should synchronize with the system of waste storage depot and should be easily maintainable.

13.2. THE PRESENT SCENARIO

13.2.1 Inefficient and Unscientific Manual Loading of Waste

In most of the cities/towns there is no synchronization between waste storage depots and transportation of waste. Waste stored in open spaces is either loaded manually or with the help of loaders in traditional trucks. Manual loading takes time and reduces the productivity of the vehicles and manpower deployed. Besides, manual handling of waste poses a threat to the health of the sanitation workers as the waste is highly contaminated. (See Photographs in Fig.13.1)

Fig. 13. 1 MANUAL LOADING OF WASTE

Loading through loading machine necessitates large quantities of waste collected in open, as could be seen from the photograph below.

Fig. 13.2 LOADING OF WASTE THROUGH FRONT END LOADER & TRUCKS

Here the loading operation is cheap but the loaders can not clean waste storage depots fully, besides loading machine damage the flooring and screen walls very often necessitating frequent repairs. If repairs are not carried out on time, the damaged flooring becomes a source of nuisance.

In cities where Dhalavs or large masonry bins are used, waste is not regularly removed from inside of such structures and loaders can not effectively function for removal of waste from the corners of such structures. Leftover (uncollected) waste putrefies and emanates foul smell causing nuisance and insanitary conditions.

13.2.2 Irregular Transportation

Cities and towns generally have limited fleet of vehicles and most of them are old necessitating frequent repairs with the result the transportation of waste does not take place regularly. The waste is generally seen lying in heaps or scattered at the unscientifically designed dust bins giving unsightly appearance besides causing nuisance and unhygienic conditions.

13.2.3 Underutilization of Fleet of Vehicles

Most of the vehicles are manually loaded and the lorries which can easily take 5 to 6 tonnes of solid waste in one trip, carry only 1-3 tonnes of waste as strict monitoring system does not exist. In several cities, small vehicles and even bullock carts are taken directly to landfill sites located at long distances. This makes the transportation operation very inefficient and uneconomical.

13.2.4 Open Trucks Cause Nuisance

Open trucks loaded with garbage wade through cities and towns as shown in Fig.13.3(a) & (b) below. They emanate fowl smell and cause nuisance to people. At places where cover material is arranged, covering of trucks is done half-heartedly and nuisance continues.

Fig. 13.3(a) GRABAGE LOADED IN OPEN TRUCKS CAUSING NUISANCE

Fig. 13.3(b) GARBAGE LOADED IN OPEN TRUCKS CAUSING NUISANCE.

13.2.5 Non-Routing of Vehicles

In cities and towns, by and large, transportation net work is illdesigned. Waste storage depots are not cleared at regular intervals and more or less fire fighting operations are carried out by local bodies. These sites are attended to more on the basis of the complaints received or pressure brought on local staff rather than following a system of regular removal of waste from waste storage depots. The system of routing of the vehicles and the clearance of the bins on day to day basis thus generally breaks down.

13.2.6 Transportation of Waste from Hotels, Restaurants, Hospitals, Construction Sites, Etc.

In many cities there is no separate system of collection and transportation of such wastes and waste from the above sites is not cleaned regularly.

13.3. MEASURES TO BE TAKEN TO IMPROVE THE SYSTEM

Looking to the present situation, transportation of waste has to be planned scientifically to bring about a total change in the existing system.

System of transportation should be such that it can be easily maintained departmentally or through private garages and the system should appropriately match with the system adopted for the storage of waste at the waste storage depots. Manual loading should be discouraged and phased out expeditiously and replaced by direct lifting of containers through hydraulic system or non-hydraulic devices or direct loading of waste into transport vehicles.

Transportation of waste should be done regularly to ensure that the containers /trolleys and dustbin sites are cleared before they start overflowing. The frequency of transportation should be arranged accordingly. The system of transportation of waste must synchronize with bulk storage of waste at the temporary waste storage depots. multiple and manual handling of waste should be avoided.

13.4. STEPS TO BE TAKEN TO MEET THE ABOVE OBJECTIVES

13.4.1. Domestic/Trade/Institutional Waste

Transportation of waste from temporary waste storage depots/sites may be planned in accordance with the frequency of containers becoming full. The locations where the containers are placed may be grouped into four categories as under:

- Containers which are required to be cleared more than once a day.
- Containers which are required to be cleared once a day.
- Containers to be cleared on alternate days.
- Containers, which take longer, time to fill and need clearance twice a week.

It may be ensured that vegetable, fruits, meat, fish market waste is removed at least once in a day.

13.4.2 Routing of Vehicles

Depending on the containers to be cleared each day, the route for lifting containers may be worked out avoiding zigzag movement of vehicles to the extent possible. This will save a lot of fuel and time.

13.4.3 Use of Vehicles in Two Shifts

All the vehicles may be utilized in two shifts to lift containers, to ensure full utilization of the fleet of vehicles and to reduce the requirement of new vehicles.

Transportation of waste during night time may be done in areas where there is serious traffic congestion during the day and it hampers solid waste management operations. Work at night will increase the productivity and reduce the cost of such service.

13.4.4 Type of Vehicles to be Used

Vehicles which can synchronize well with containers placed at temporary waste storage depots should be utilized for transportation to prevent multiple handling of waste. The selection of the type of vehicles should also be done keeping in mind the quantity of waste to be transported, the distances to be travelled, the road widths, road conditions, work shop facilities, etc.

In cities above 5 lac population, hydraulic vehicles could be used. Following type of vehicles or similar vehicles could be used for transportation of waste.

(i) Container lifting devices such as Dumper placers/skip lifters or similar other vehicles may be used for transportation of large size containers to transfer stations or to disposal sites as illustrated in Fig.13.4.

(ii) At places where small size containers of 0.5 to 1.0 cu.m. may have been placed, the refuse collector machine without compaction devices of 6 to l5 cu.m. capacity having top or back loading facility may be used. This vehicle, instead of transporting the container as shown in Fig.13.4 above lifts and unloads the contents of the small container into the body of the vehicle through a hydraulic system and puts the empty container back in place as shown in Fig.13.5.

Fig. 13.4 TRANSPORTATION OF LARGE CLOSED-BODY CONTAINER

FIG. 13.5 LIFTING OF SMALL CONTAINER FOR EMPTYING THE CONTENTS

(iii) ***Transportation from Congested Areas***

Local bodies should provide facility of direct loading of waste in small vehicles in the congested areas where small vehicles may be parked at suitable locations during primary collection and sweepers may be directed to transfer the waste from the hand carts directly into vehicles, as shown in Fig. 13.6 below.

Fig. 13.6 PRIMARY COLLECTION OF WASTE THROUGH A SMALL VEHICLE

The waste so collected in small vehicles may be taken to the nearest transfer station to transfer the contents into a large container by using a ramp to reduce the cost of transportation.

(iv) In small cities with poor repairs and maintenance facility, where hi-tech vehicles may not work efficiently, tractor-trolley combination or lifting of containers or toeing of containers by tractors may be utilized. Simple hydraulic tipping-trailers are recommended to avoid manual unloading at Processing Plants or disposal sites.

13.4.5 Bio-Medical Waste From Hospitals, Nursing Homes, Health Care Establishments Etc.

Transportation of bio medical waste has to be arranged by waste producers or their associations. The instructions contained in the Biomedical Waste (Management and Handling) Rules 1998 may be followed. The recommendations made in the Chapter-7 on biomedical waste may be followed. Adequate protective clothing must be used by the staff handling biomedical waste as illustrated in the photograph in Fig. 13.7:

Fig. 13.7 STAFF ENGAGED IN TRANSPORTATION OF BIOMEDICAL WASTE

13.4.6 Transportation of Waste From Hotels & Restaurants

Hotels and restaurants waste should be collected once or twice daily through a contract given by the associations of hotels and restaurants, or at their request by local bodies on cost recovery basis. Doorstep collection system may be introduced for collection of such waste. Either refuse collector with back loading facility or motor vehicle with close body may be used. The entire collection and transport system could be privatized and rates may be prescribed by the associations or local bodies. 33% spare vehicles may be kept in reserve to ensure reliable service.

13.4.7 Transportation of Construction Waste and Debris

Disposal of construction and demolition waste and debris is the liability of waste producers. If such waste is not promptly removed within a reasonable time prescribed by the local body, it may be removed by the local bodies themselves on full-cost-recovery basis. One of the following methods may be adopted for transportation of construction waste and debris:

- In very large cities where a skip-renting system can be introduced, the skips may be transported by hydraulic system at a time mutually agreed upon between the local body and waste producer. See photograph in Fig. 13.8.

Fig.13.8 SKIP UTILIZED FOR TRANSPORTATION OF CONSTRUCTION WASTE/DEBRIS.

- When sufficient cost-recovery fee is deposited in advance by waste producer for removal of construction waste, such waste may be loaded mechanically into skips or vehicles using front-end-loaders. One front-end-loader and 3 to 4 trucks can transport 100 to 150 tonnes of construction waste in one shift.

- In small cities under 5 lac population, construction waste may be manually loaded into trucks/ or tractor trolleys and transferred to disposal sites.

Since all such waste must be cleared sooner or later, the more promptly this is done, the cleaner the city will be and there will be less traffic obstruction.

13.4.8 Transportation of Waste from Narrow Lanes

Quite often small quantities of waste are disposed of in narrow lanes, which cannot be removed by sending out the usual transport vehicles. Loading rickshaws or traditional carts or animals may be used for removal of such waste manually but very promptly.

13.5. SETTING UP OF TRANSFER STATIONS

In large cities where disposal sites are more than 10 km. away from the city boundary and smaller vehicles are used for transportation of waste, it may prove economical to set up transfer stations to save transportation time and fuel provided such cities have a good performance record of vehicle maintenance and adequate facilities to maintain large size vehicles and containers. Large size 15 to 20 cu. m. containers could be kept at transfer stations to receive waste from small vehicles. A ramp facility may be provided to facilitate unloading of vehicles or dumper places containers, directly into large containers at transfer station. Construction of complicated and expensive transfer stations must be avoided.

The requirements of large containers and vehicles may be worked out on the basis of the total quantity of waste expected to be brought to the transfer station and the number of trips the vehicles will be able to make in two shifts each day.

13.6 LIFTING OF WASTE FROM TRANSFER STATION

In cities where transfer stations have been provided, to economize the cost of transportation of waste, large containers of 15 to 20 cu.m. may be used and lifted by specially designed vehicles which can carry big size containers duly cleared by regional transport authorities.

13.7 WORKSHOP FACILITY FOR VEHICLES MAINTENANCE

All local bodies must have adequate workshop facilities for the maintenance of their fleet of vehicles and containers, handcarts etc. Such facilities may be created by local bodies departmentally or through a contractual arrangement. The workshop, public or private, should have adequate technical staff, spares and preventive maintenance schedules to ensure that at least 80% of the vehicles remain on the road each day and the down time of repair/maintenance is minimised to the extent possible. Spare assemblies should be kept available which could be given as replacements until necessary repairs are carried out. The workshop should be preferably headed by an automobile or mechanical engineer.

Cities which use hydraulic equipments such as dumper placers, refuse collectors, etc., should as far as possible give contract to the manufacturers of the equipment or to their, authorized agents or to reliable workshops in the city for the repairs and maintenance of vehicles to keep the fleet of vehicles in a good working condition. In such cases, daily checking, 15 days checking, checking after 2000 Kms and 4000 Kms. may be carried out departmentally and checking after 20,000 Kms could be got done through a private garrage which has been given contract. Generally this will take about an year when some major repairs would be required in the vehicles, which could be done through a contractor.

In cities where such an arrangement is not possible or local bodies desire to maintain the fleet of vehicles departmentally, they should appoint adequate technical staff, in the workshop for maintenance of the fleet of vehicles as shown in Table 13.1 below and should have a schedule of preventive maintenance for the vehicles as shown in Annexure-13.1. This Annexure shows the items to be checked daily, fortnightly/ after 2000 Kms., after the 4000 kms, etc., in case of hydraulic mounted vehicles. Similar schedule of maintenance for the trucks utilized for handling garbage is given in Annexure-13.2, which also shows the preventive maintenance schedule after running 24000 Kms.

Table-13.1

STAFF REQUIREMENT FOR MAINTENANCE OF VEHICLES

SR. NO	DESIGNATION	VEHICLES 5	VEHICLES 10	VEHICLES 25	VEHICLES 50
1.	Fitters	1	1	4	6
2.	Electricians	1	1	2	2
3.	Tyre fitters	-	-	1	2
4.	Body smith	-	-	1	1
5.	Welder	-	-	1	1
6.	Supervisors	-	1	2	2
7.	Mechanics	1	1	2	2
8.	Helpers/Cleaners	1	2	4	6
9.	Store clerks	-	-	-	1
10.	Maintenance Incharge	-	-	-	1

Team incentives should be introduced in departmental workshops to ensure that more than 80% of vehicles remain on the road throughout the month.

Type of standard tools required in the workshop.

If local bodies decide to maintain the fleet of vehicles departmentally, the minimum tools required in the workshops are given in Annexure-13.3

The workshops should preferably be run in more than one shift. Technical staff as per the requirement may be kept in the second or third shift to ensure optimum utilization of the fleet of vehicles of local bodies.

Since waste-transport vehicles have a useful life of 8-10 years, financial planning must ensure timely replacement of vehicles to minimise down time and repair costs.

13.8 FLEET OF VEHICLES TO BE MAINTAINED

Every local body should work out the need of vehicles as under.

(i) No. of containers placed in the city.

(ii) No. of containers to be removed on day to day basis.

(iii) No. of containers to be lifted 1st, 2nd and/or 3rd shift.

(iv) Distance to be travelled.

(v) No. of containers a vehicle can lift in one shift.

Normally during the busy day time 4 to 5 containers can be transported from the city to the processing or disposal site if distance to be travelled is within 5 to 9 Kms. The no. of trips could be more if the distance to be travelled is less than 5 Kms. And could be less if distance to be travelled is more than 9 Kms. More trips could be made if transportation is carried during night time when the roads are free from traffic flow.

(vi) No. of vehicles required to lift the required No. of containers in two shifts.

(vii) Stand by vehicles required @ 30% of the total vehicles to be used each day.

(viii) Total no. of vehicles required on the fleet.

It must be ensured that local bodies remove daily quantities of waste equal to the total quantity of waste produced each day to avoid any backlog, which can be estimated by taking all the vehicles small or big, carrying waste to the waste treatment/disposal site through a public weigh bridge for at least 3 days continuously or correctly estimate the quantities of waste transported each day taking into consideration the volume and density of the waste being transported on day-to-day basis. Some studies, conducted by NEERI, Nagpur in past have estimated waste generation rates as per Table 13.2.

TABLE 13.2

POPULATION RANGE	AVERAGE PER CAPITA WASTE GENERATION (IN GRAMS.)
1,00,000 to 5,00,000	210
5,00,000 to 10,00,000	250
10,00,000 to 20,00,000	270
20,00,000 to 50,00,000	350
50,00,000 and above	500*

Source : NEERI. Strategy. Report on SWM in India

*** Presently 600 gm.**

13.9 PARKING OF WORKSHOP VEHICLES

Small cities having a few vehicles can have parking in the workshop itself; but in big cities where large distances are to be travelled, it is desirable to have parking depots in different parts of the city to reduce dead mileage of vehicles. Cities above 5 lacs population should think of having more than one depot for parking of vehicles in different directions of the city. Cities above 2 million should think of having at least 3 to 4 such depots to reduce the congestion in the workshop and also to cater the needs of the different sectors of the city from the depot close by. The arrangements for putting fuel in such vehicles could also be made locally either by having fuel filling station at each depot or having a working arrangement with a private petrol pump to provide fuel on contractual basis to municipal vehicles. This will save lot of dead mileage and add to the efficiency of transport system.

ANNEXURE – 13.1.

Hydraulic Vehicle Inspection Schedule

Daily Checking.

I. Water topping in radiator

II. Engine Oil level

III. Visual type pressure to be checked

IV. Complaint of driver to be attended

For Hydraulic System checking.

I) Check oil level of oil tank

II) Check leakage of oil; change oil seal if required.

III) Tighten all connections

IV) Check hydraulic operations; set pressure, if required.

2000 KM Visual checking or 15 days checking.

A. Engine

1. Check fuel line leakage
2. Check engine oil leakage
3. Check water leakage
4. Start engine, check and adjust engine idling and stop level
5. Change front and rear engine foundation
6. Check pressure leakage and cure it.

B. Admission

1. Check clutch pedal free play and take judgement for clutch dish plate.
2. Check gear and diff. Oil leakage and cure it.
3. Check joint line play and change it.
4. Check all joint bolt and tight/change.

C. Brake

1. Check leakage in brake system
2. Check liners and adjust brake
3. Clean air tank

D. Fuel

Check fuel tank cap & ring and change

E. Electrical

1. Check fan belt and tight it
2. Check level of electrolyte and top up
3. Check rod of alternator/dynamo
4. Check all lights and switches.

F. Chassis

Check shackle brackets, bolts, spring, leaf spring centre and tight U bolts.

G. Tyre

1. Fill up air in tyre
2. Tight wheel nuts
3. Remove stones between two tyres
4. Change polish tyres

H. Body

Tight bumper, check seats and rest of necessary, tight it and if necessary change it. Check steering of the bolt, side signal and horn. Check windscreen glass.

4000 Km checking (General Checking)

A. Engine

1. Clean engine, check oil leakage, if informed change engine oil and oil filter if in mileage.
2. If oil changed in vehicle, do as per under.

   a) Check tappets
   b) Clean fuel filter bowl
   c) Clean feed pump pre filter

3. Clean air cleaner and change oil
4. Check oil level of fuel pump. Tight bolts of fuel pump coupling.
5. Check fuel connection including injector pipes
6. Check unloader valves; brake pedal valve, dual brake valve, and stand brake and system protection valve.
7. Check engine oil pressure in cold position and also check blow back and smoke
8. If there is no dipstick fit it
9. Check engine running and accelerator connection
10. Check radiator/water pump for leakage, grease water ump bearing, check radiator hose pipe and radiator support.
11. Check dumper pulley
12. Check timing covers oil seal for leakage
13. Clean diesel tank from outer side, check its cap & ring, and if needed, change it.
14. Check engine foundation and bolts
15. Clean oil breather and if needed replace it.

B. Brake

1. Check oil in hydraulic brake system. Clean brake oil reservoir tins and also checks for leakage.
2. Drain pressure tank. Check brake pedal pin or bolt/change.
3. Check all pipe connection of brake system. Also check brake diaphragm for leakage, check brake setting/change.
4. Check brake drum and liner and set brake.
5. Check brake pedal free travel.
6. Tight all axle studs, if necessary change axle shaft and fit it with spring washer.
7. Open front hubcap & grease if in vehicle oil change.
8. Check air pressures and adjust it.

C. Steering

1. Check steering connection and foundation bolts, ball pin with 130 to 150 PS, pressure.
2. Oil king pin and steering box.

D. Transmission system: clutch, gear, joint, differential.

1. Check clutch pedal plug, gear level, thrust bearing, clutch rod sockets, gear top and gears round bolts.
2. Grease clutch thrust bearing and check fork.
3. Check gear oil and top up. Check for leakage of gear oil seal and flange nut.
4. Check cover of gear die, if it is not, then fit it.
5. Check drives oil and top U. Check pinion, oil seals and covers for leakage.
6. Check breather of gear and diff.
7. Check propeller shaft, U-bolts, joint bearing and all unique joint bolts and tight and if needed, change it.

E. Lubrication

Lubricate all the points in chassis.

F. Spring

Tight all spring, U bolts with T spanner, check springs crossmember bolts, body bolts and bumper bolts and tight.

G. Electrical

1. Clean battery, top up electrolyte, check gravity clean terminals and grease it.
2. Check dynamo alternator changing rate and fan belt.
3. Check self starter and starter foundation studs.
4. Check all lights, one off switches, fuse system and wiring, clean roof light glass.

H Tyre

1. Check tyre for puncture, fill pressure if needed tight wheel nut.
2. Change tyre if it is polish/wear out/damage
3. Remove stone if there is in between two tyres.

ANNEXURE-13.2

Schedule of Maintenance of trucks & vehicles.

I) Daily checking

1. Water hopping in radiator
2. Engine oil level.
3. Tyre pressure (visually)
4. Complain of driver to be attended.

II) Hydraulic system

1. Check oil level or oil tank.
2. Check leakage, change oil seal if required.
3. Tighten all connection.
4. Check hydraulic operation, set pressure if required.

Visual Checking to be carried out after every 2000 Kms. or 15 days

A. Engine

1. Check fuel line leakage
2. Check engine oil leakage
3. Check water leakage
4. Start engine, check and adjust engine idling and stop lever
5. Change front and rear engine foundation
6. Check pressures leakage and cure it.

B. Transmission

1. Check clutch pedal free play & take judgement for clutch dish plate.
2. Check gear & diff. Oil leakage & cure it.
3. Check joint line play and change it
4. Check all joint bolt and tight/change

C Brake

1. Check leakage in brake system
2. Check liners and adjust brake
3. Clean air tank

D. Fuel

check fuel tank capand ring and change.

E. Electrical

1. Check fan belt and tight it.
2. Check level of electrolyte and top up
3. Check rod of alternator/dynamo
4. Check all lights and switchers

F. Chassis.

Check shackle brackets, bolts, spring leaf spring centre & tight U bolts.

G. Tyres

1. Fill up air in tyre
2. Tight wheel nuts
3. Remove stones between two tyres
4. Change polish tyres
5. Report for which tyres wears because of mechanical defects.

H. Body

Tight bumpers, check steering of the bolt, side signal and horn. Check wind screen glass.

Checking to be carried out after every 4000 Kms.

A. Engine

1. Clean engine, check oil leakage, change engine oil and oil filter if in mileage.
2. When you change oil in vehicle do as under:-
    a) Check Tappets
    b) Clean fuel filter bowl
    c) Clean FD pump pre filter
3. Clean air cleaner and change oil.
4. Check oil level of fuel pump. Tight bolts of fuel pump coupling.
5. Check fuel connection including injector pipes.
6. Check unloader valve, brake pedal valve, duel brake valve, stand brake and system protection valve.

7. Check engine oil pressure in cold position and also check blowback and smoke.
8. If there is no dipstick fit it.
9. Check engine running and accelerator connection.
10. Check radiator/water pump for leakage, grease water pump bearing, check radiator hose pipe and radiator support.
11. Check dumper pulley.
12. Check timing covers oil seal for leakage.
13. Clean diesel tank from outer side and check its cap and ring, if needed change.
14. Check engine foundation and bolts.
15. Clean oil breather, if needed, replace it.

B. Brake

1. Check oil in hydraulic brake system. Clean brake oil reservoir tin and also check for leakage.
2. Drain pressure tank. Check brake pedal pin or bolt/change.
3. Check all pipe connection of brake system. Also check brake diaphragm for leakage, check brake setting/change.
4. Check brake drum and liner and set brake.
5. Check brake pedal free level.
6. Tight all axle studs, if necessary change axle shaft and fit it with spring washer.
7. Open front hubcap and grease if in vehicle in which oil change.
8. Check air pressure and adjust it.

C. Steering

1. Check steering connection and foundation bolts. Tight ball pin with 130 to 150 PS, Pressure.

2. Oil king pin and steering box..

D. Transmission system : Clutch, Gear, Joint, and Differential.

1. Check clutch pedal plug, gear lever, thrust bearing clutch rod sockets, gear top and gear round bolts.
2. Grease clutch thrust bearing and check fork.
3. Check gear oil and top up. Check for leakage of oilseal and flange nut.
4. Check cover of gear die, if it is not there, fit.
5. Check diff. Oil and top up. Check pinion, oil seal and cover for leakage.
6. Check breather of gear and diff.
7. Check propeller shaft, U joint bearing and all unique joint bolts and tight if needed change.

E. Lubrication

Lubricate all the points in chassis.

F. Spring

Tight all spring U bolts with T spanner, check springs, cross member bolts, body bolts and bumper bolts and tight.

G. Electrical

1. Clean battery. Top up electrolyte, check gravity clean terminals and grease it.
2. Check dynamo/alternator changing rate and fan belt.
3. Check self-starter and starter foundation studs.
4. Check all lights, on off switches, fuel system and wiring, clean roof light glass.

H. Tyre

1. Check tyre for puncture, fill pressure if needed tight wheel nut.
2. Change tyre if it has worn out/damaged.
3. Remove stone if they're in between two tyres.

Inspection for maintenance at 2400 Kms.

A. Engine

1. Check all diesel and oil pipes for leakage and clamp the same properly.
2. Clean the feed pump pre filter.
3. Change diesel filter in mileage.
4. Change in the injectors.
5. Check Bosch pump timing, its mounting and tight timing bolt.
6. Open the bosch pump cover and do oiling
7. Change air cleaner
8. Change the oil and oil filter in mileage
9. Fit the dipstick if missing.
10. Change valve cover packing.
11. Clean the breather.
12. Do tappet setting (0.20") for Henna Engine concern the respective authority.
13. Check exhaust manifold and silencer and repair it if needed. Check and set accelerator connections and oil it. Check water pump pulley, fan and fan bolt.
14. Change water pump if needed or regrease it.
15. Tight cylinder head nuts in recommended order
16. Change water pump if needed or regrease it.
17. Tight cylinder head nuts in recommended order.
18. Change, unloader valve, hand brake valve, dual brake valve, system protection valve, if in mileage or check for any leakage's
19. Check system air pressure, adjust the system air pressure.
20. Change the units, which are in mileage.
21. Open brake line air filters clean/change and refit.
22. Check/change brake pedal valve.

B. Brake

1. Over haul both front, rear brakes and change the bearing grease.
2. Change the front axle if in mileage.
3. Change the camshaft in mileage and change brake chambers in mileage or leakage.
4. Check and change oil seals and its rings and required wheel bearing, also set wheel bearing play.
5. Check all brake hoses and change if required. Set its position to avoid any wearing.
6. Check and tight or replace all chassis pot pipe.
7. Check hub, axle stud and replace where necessary.
8. Axle stud should procured 5/10@ check axle shaft holes and willing if required replace axle shaft.
9. Check sluck adjustment and replace if required.
10. Check/replace pr.meter.
11. Drain the air tank.
12. Check/replace brake pedal fulcrum pin and bolts.

C. Clutch and gears.

1. Change clutch disc plate/prt.plate/gear box if in mileage on having defect.
2. Check/replace clutch pedal bush.
3. Check/replace clutch rod socket. Jaw pin.
4. Check/replace flywheel ring.
5. Check/replace the bearing fork.
6. Tight gem housing bolts with spring washer.
7. Set the clutch and adjust free play (3.75").
8. Top up change gear oil.
9. Fit geardie inspection play.

10. Check/change gear die.
11. Check geardie bolt/stud. Check/tight gear lever rock bolt.
12. Check/change/tight joint bolt, check gearbox flange for hole and if required change.

D. Differential and steering.

1. Check milling and flange hole of pro.shaft, york and centre bearing and change.
2. Check/change joint bolts.
3. Check/change centre bearing bolts.
4. Check steering connection, remove play and do steering reloading.
5. Check and change all steering ends.
6. Tight ball pin nut with 130/150 PSI pressure.
7. Top/change steering oil
8. Top /change dif. Oil.
9. Change differential given in mileage on defect
10. Check/tight/change/sackle bracket bolts.
11. Check/tight/change I bolts and U bolts with help of T spanners.
12. Check leaf springs and chassis and give reports.
13. Tight diff. Tube studs.

E. Diesel, tank, greasing/brake chamber.

1. Do greasing in suspension, accelerator, and in need full units.
2. Drain diesel tank and change it if leakage.
3. Clean diesel tank plug net.
4. Fit rubber packing both diesel tank, bolt and tank.
5. Tight diesel tank bracket and mounting bolts.
6. Check/change rubber O/F pipe.
7. Check/change diesel tank cap and return spring and rubber rings.
8. Change front brake chamber in mileage or leakage.

F. Radiator/Engine foundation/Coil/Kingpin.

1. Change radiator and hose pipes.
2. Change/check front & rear engine foundation bush meter cones.
3. Check/change engine foundation pin and fit quarter pin.
4. Check and change engine side support bolts and its pads.
5. Check/change radiator mounting pads.
6. Adjust the king pin and do wheel alignment.

G. Auto electric.

1. Check/change starter/alternator/batteries.
2. Remove all the batteries from battery box deems the battery box and refit.
3. Check/change starter/chassis earthing wire, main wire, jumper wires.
4. Check/change wire socket battery terminal and apply jelly.
5. Top up the battery with dist. Water mix upto 1/2" above plates.
6. Check/change starter push button.'check/change fan belts.
7. Check/change fan belts.
8. Check/change lighting switches, fuse and junction wiring.
9. Check/change route board/rood light/brake light/parking light/head light/side signal/dipper switch/all tube lights and covers.
10. Clean head light seal beam, roof light glass, tube light covers, and adjust headlights.

H. Body

1. Check and replace or repair driver seats.
2. Check driver seat's gear and oil it.
3. Check/change side glass, looking glass and all glasses.
4. Check/repair/change grill, bonnet, front rear bumpers, horn, horn bulb, windscreen glass and its bracket, lock of driver cabin doors.
5. Fit horn with proper cleaning and position.

I. Tyre

1. Change punctured tyres.
2. Check tyre pressure and check/changer wheel plates if required.
3. Change worn out, polish, damaged tyres.
4. Remove stones, bolts from tyres.

J. Cleaning/paint.

1. Cleaning all the glass from both the sides.
2. Paint the required part with some colour.

ANNEXURE – 13.3

Minimum equipments/tools required for workshop to maintain a fleet of up to 50 vehicles.

1. 5 HP Air Compressor
2. Car washing machine
3. 150 amp. Welding machine for fabrication and body work.
4. One ton capacity lib crane preferably mechanically operated.
5. Battery charging machine having capacity of 12 Volt, 6 batteries, battery tester such as hydro meter, volt meter, etc.
6. Working table along with vice for repairing aggregates.
7. Tube vulcanizing machine tyre inflator.
8. Pneumatic grease pump, grease gun, etc.

CHAPTER 14
COMPOSTING

14.1 INTRODUCTION

The organic content of Municipal Solid Waste (MSW) tends to decompose leading to various smell and odour problems. It also leads to pollution of the environment. To ensure a safe disposal of the MSW it is desirable to reduce its pollution potential and several processing methods are proposed for this purpose. Composting process is quite commonly used and results in production of a stable product - compost which depending upon its quality can be used as a low grade manure and soil conditioner. The process results in conservation of natural resources and is an important processing method, especially in agricultural and horticultural areas.

In the case of individual households, small establishments and colonies, vermi-composting which involves the stabilisation of organic solid waste through earthworm consumption for conversion of the organic material to worm casting is being increasingly preferred. This process is discussed in detail in Chapter 16.

14.2 PRINCIPLES OF COMPOSTING – MANUAL AND MECHANISED METHODS

Decomposition and stabilisation of organic waste matter is a natural phenomenon. Composting is an organised method of producing compost manure by adopting this natural phenomenon. Compost is particularly useful as an organic manure which contains plant nutrients (Nitrogen, Phosphorous and Potassium) as well as micro nutrients which can be utilized for the growth of plants (Gotaas 1956). When used in conjunction with chemical fertilisers optimum results are obtained.

Composting can be carried out in two ways i.e., aerobically and anaerobically. During aerobic composting aerobic micro-organisms oxidise organic compounds to Carbon di oxide, Nitrite and Nitrate. Carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to exothermic reaction, temperature of the mass rises. During anaerobic process, the anaerobic micro organisms, while metabolising the nutrients, break down the organic compounds through a process of reduction. A very small amount of energy is released during the process and the temperature of composting mass does not rise much. The gases evolved are mainly Methane and Carbon di oxide. An anaerobic process is a reduction process and the final product is subjected to some minor oxidation when applied to land.

14.3 INDORE & BANGALORE METHODS OF COMPOSTING

Manual composting was systematised by Howard & his associates. It was further developed by Acharya & Subrahmanyam and the methods are conventionally referred as Indore and Bangalore methods of composting.

14.3.1 Bangalore Method

This is an anaerobic method conventionally carried out in pits. Formerly the waste was anaerobically stabilised in pits where alternate layers of MSW and night soil were laid. The pit is completely filled and a final soil layer is laid to prevent fly breeding, entry of rain water into the pit and for conservation of the released energy. The material is allowed to decompose for 4 to 6 months after which the stabilised material is taken out and used as compost.

14.3.2 Indore Method

This method of composting in pits involves filling of alternate layers of similar thickness as in Bangalore method. However, to ensure aerobic condition the material is turned at specific intervals for which a 60 cm strip on the longitudinal side of the pit is kept vacant (Fig.14.1). For starting the turning operation, the first turn is manually given using long handled rakes 4 to 7 days after filling. The second turn is given after 5 to 10 more days. Further turning is normally not required and the compost is ready in 2 to 4 weeks.

In the urban areas, due to extensive provision of water carriage system of sanitation, night soil is not available. Composting of MSW alone is hence often carried out. Aerobic composting of MSW is commonly carried out in windrows.

14.3.3 Comparison of the Methods

The Bangalore method requires longer time for stablisation of the material & hence needs larger land space, which is in short supply in urban areas. The gases generated in this anaerobic process also pose smell & odour problems.

The Indore method on the other hand stabilises the material in shorter time & needs lesser land space. As no odourous gases are generated in this process, it is environment friendly & hence commonly preferred.

While the organic matter is stabilised during the composting process, the moisture content also changes. The non decomposables are also rejected. Hence the quantity of compost is much lesser than the input & is normally around 50%, and the exact value depends upon the characteristics of the input material.

14.3.4 Windrow Composting

The organic material present in Municipal Waste can be converted into a stable mass by aerobic decomposition. Aerobic micro organisms oxidize organic compounds to Carbon di oxide and oxides of Nitrogen and Carbon from organic compounds is used as a source of energy, while Nitrogen is recycled. Due to exothermic reactions, temperature of mass rises.

In areas/regions were higher ambient temperatures are available, composting in open windrows is to be preferred. In this method, refuse is delivered on a paved/unpaved open space but levelled and well drained land in about 20 windrows with each windrow 3m long x 2m wide x 1.5m high, with a total volume not exceeding 9.0 cu.m.

Each windrow would be turned on 6th & 11th days outside to the centre to destroy insects larvae and to provide aeration. On 16th day, windrow would be broken down and passed through manually operated rotary screens of about 25mm square mesh to remove the oversize contrary material. The screened compost is stored for about 30 days in heaps about 2m wide x 1.5m high and up to 20m long to ensure stabilization before sale.

14.4 FACTORS AFFECTING THE COMPOSTING PROCESS

14.4.1 Organisms

Aerobic composting is a dynamic system wherein bacteria, actinomycetes, fungi and other biological forms are actively involved. The relative preponderance of one species over another depends upon the constantly changing food supply, temperature and substrate conditions. Facultative and obligate forms of bacteria, actinomycetes and fungi are most active in this process. In the initial stages mesophilic forms predominate and thermophilic bacteria and fungi soon take over except in the final stage of composting. Except when the temperature drops, actinomycetes and fungi are confined to 5 to 15 cm outer surface layer. If the turning is not carried out frequently the actinomycetes and fungi in these layers register increased growth imparting it typical greyish white colour. Thermophilic actinomycetes and fungi are known to grow well in the range of 45 to 60^{o} C.

Different organisms are known to play predominant role in breaking down different constituents of municipal solid waste. Thermophilic bacteria are mainly responsible for the breakdown of proteins and other readily biodegradable organic matter. Fungi and actinomycetes play an important role in the decomposition of cellulose and lignin. The actinomycetes common in compost are Streptomyces sp. and Micromonospora sp. the latter being more prevalent. The common fungi in compost are Thermonomyces sp., Penicillium dupontii and Asperigallus fumigatus. Majority of these organisms responsible for composting are already present in municipal solid waste. Not much information is available regarding the organisms active in anaerobic composting, though many of the organisms responsible for anaerobic decomposition of sewage sludge will be active here also, and differences are expected due to the concentration of nutrients present and the temperature conditions.

14.4.2 Use of Cultures

During the development of composting process various innovators came forward with **inoculum, enzymes** etc., claimed to **hasten the composting process. Investigations carried out by various workers have shown that they are not necessary.** The required forms of bacteria, actinomycetes and fungi are indigenous to MSW. Under proper environmental conditions the indigenous bacteria adapted to MSW rapidly multiply, as compared to the added cultures which are more attuned to controlled laboratory conditions and carry out decomposition. The process is dynamic and as any specific organism can survive over a specific range of environmental conditions, as one group starts diminishing, another group of organisms starts flourishing. Thus, in such a mixed system appropriate life forms develop and multiply to keep pace with the available nutrients and environmental conditions. Hence, addition of similar and extraneous organisms in the form of inoculum is unnecessary. However, such inoculum will be required during composting of industrial and agricultural solid waste which do not have the large mix of indigenous bacterial population.

14.4.3 Moisture

The moisture tends to occupy the free air space between the particles. Hence, when the moisture content is very high, anaerobic conditions set in. However, the composting mass should have a certain minimum moisture content in it for the organisms to survive. The optimum moisture content is known to be between 50 to 60 % . Higher moisture content may be required while composting straw and strong fibrous material which soften the fibre and fills the large pore spaces. Higher moisture content can also be used in mechanically aerated digesters. In anaerobic composting the moisture content used will depend upon the method of handling and whether it is carried out in the open or in closed container.

14.4.4 Temperature

The aerobic decomposition of a gram mole of glucose releases 484 to 674 kilo calories (kcal) energy under controlled conditions, while only 26 kcal are released when it is decomposed anaerobically. Municipal solid waste is known to have good insulation properties and hence the released heat results in increase in temperature of the decomposing mass. As some of the heat loss occurs from the exposed surface, the actual rise in temperature will be slightly less. When the decomposing mass is disturbed, as during turning of windrows, the resultant heat loss results in drop in temperatures. Under properly controlled conditions temperatures are known to rise beyond 70^{o}C in aerobic composting. Under properly controlled conditions temperatures are known to rise beyond 70^{o}C in aerobic composting. During anaerobic composting as the released heat is quite small and as part of it is lost from the surface only a marginal rise in temperature occurs.

This increased temperature results in increased rate of biological activity and hence results in faster stabilisation of the material. However, if the temperature rise is very high, due to inactivation of the organisms & enzymes the rate of activity may decrease. The studies carried out have shown that the activity of cellulose enzyme reduces above 70^{o}C and the optimum temperature range for nitrification is 30^{o} to 50^{o}C beyond which nitrogen loss is known to occur. The temperature range of 50^{o} to 60^{o}C is thus optimum for nitrification and cellulose degradation.

The high temperature also helps in destruction of some common pathogens and parasites (Table 14.1). According to Scott, during aerobic composting when the material is turned twice in 12 days ***Entamoeba histolytica*** is killed and the eggs of ***Ascaris lumbricoides*** are killed in 36 days when turned thrice. The studies carried out at NEERI have shown that the destruction of these organisms is not ensured under anaerobic conditions.

Knoll has proved that the high temperature and long retention during aerobic composting along with the antibiotic effect results in destruction of parasites and pathogens.

Thus, if the process is so controlled that the temperature is kept between 50^{o} to $60\ ^{o}$C for 5 to 7 days, destruction of pathogens and parasites can be ensured.

14.4.5 Carbon/Nitrogen (C/N) Ratio

The organisms involved in stabilisation of organic matter utilise about 30 parts of carbon for each part of nitrogen and hence an initial C/N ratio of 30 is most favourable for composting. Research workers have reported the optimum value to range between 26-31 depending upon other environmental conditions. The C/N ratio considers the available carbon as well as the available nitrogen while the available carbon and nitrogen in the MSW may vary from sample to sample. Whenever the C/N ratio is less than the optimum, carbon source such as straw, sawdust, paper are added while if the ratio is too high, the sewage sludge, slaughter house waste, blood etc. are added as a source of nitrogen.

Table 14.1 : Temperature and Time of Exposure Needed for Destruction of some Common Parasites and Pathogens.

Organisms	Time and Temperature for destruction
1. S.typhosa	No growth beyond 46^{O}C, death in 30 minutes at 55-60^{O}C and 20 minutes at 60^{O}C,destroyed in a short time in compost environment.
2. Salmonella sp.	In 1 hour at 55^{O}C and in 15-20 minutes at 60^{o}C
3. Shigella sp.	In 1 hour at 55^{O}C .
4. E. Coli	In 1 hour at 55^{O}C and in 15-20 minutes at 60^{o}C
5. E.histolytica cysts	In few minutes at 45^{O}C and in a few seconds at 55^{O}C.
6. Taenia saginata	In a few minutes at 55^{O}C.
7. Trichinella spiralis larvae	Quickly killed at 55^{O}C, instantly at 60^{O}C.
8. Br.abortus or Br.suis	In 3 minutes at 62-63^{O}C and in 1 hour at 55^{o}C
9. Micrococcus pyogenes var. aureus	In 10 minutes at 54^{O}C.
10. Streptococcus pyogenes	In 10 minutes at 54^{O}C.
14. Mycobactercum tuber-culosis var. hominis	In 15-20 minutes at 66^{O}C or after momentary heating at 67^{O}C.
12. Corynebacterium diptheriae	In 45 minutes at 55^{O}C.
13. Necator americanus	In 50 minutes at 45^{O}C .
14. A.lumbricoides eggs	In 1 hour at 50^{O}C.

14.4.6 Aeration

It is necessary to ensure that oxygen is supplied throughout the mass and aerobic activity is maintained. During the decomposition, the oxygen gets depleted and has to be continuously replenished. This can be achieved either by turning of windrows or by supplying compressed air. During the turning, it is necessary to bring inner mass to the outer surface and to transfer the outer waste to the inner portion. (Fig. 14.2) . In case of artificial air supply the quantity of air supply is normally maintained at 1-2 cu.m./day/kg of volatile solids.

Artificial air supply requires enclosing decomposing mass in containers which is quite costly. Hence in Indian conditions the decomposition is commonly carried out in open windrows. Studies at NEERI have shown that the optimum turning interval which will reduce the cost and simultaneously maintain aerobic conditions is 5 days.

14.4.7 Addition of Sewage and Sewage Sludge

The optimum C/N ratio for composting is 25-30. MSW in developed countries has a C/N ratio of nearly 80. To bring it down to the optimum value and to reduce the cost of sewage sludge treatment, it is mixed with sewage sludge (C/N = 5 to 8). MSW in India, on the other hand has an initial C/N ratio of around 30 which does not need blending. If such a mixing is done, C/N value may reduce below 20, when a loss of nitrogen in the form of ammonia occurs. (Table 14.2)

Tables 14.2 : Nitrogen Conservation in relation to C/N Ratio

Initial C/N Ratio	Final % of Nitrogen (N) (dry weight basis)	% N loss
20	1.44	38.8
20.5	1.04	48.1
22	1.63	14.8
30	1.21	0.5
35	1.32	0.5
76	0.86	-

Addition of sewage sludge increases smell and odour problems. It will also increase handling and transportation cost. Even if sewage is used as a source of moisture, bulk of sewage will still have to be treated. The sewage often contains waste waters from industries which contain hazardous constituents which will pose problems in the composting process and compost quality. In view of the above, addition of sewage and sludge is not desirable in India.

14.5 CONTROL OF COMPOSTING PROCESS

The composting is normally taken to be complete when the active decomposition stage is over and the C/N ratio is around 20. If the C/N ratio of compost is more than 20, the excess carbon tends to utilise nitrogen in the soil to build cell protoplasm. This results in loss of nitrogen of the soil and is known as robbing of nitrogen in the soil. If on the other hand the C/N ratio is too low the resultant product does not help improve the structure of the soil. It is hence desirable to control the process so that the final C/N ratio is around 20.

The composting process should also be so controlled that the temperature of the decomposing mass remains between 50^o-$60\ ^oC$ for at least a week. This ensures the destruction of any parasites or pathogens present in the decomposing mass.

During the operation of the process, aerobic conditions should be maintained by controlling the aeration so that smell & odour as well as fly problems do not arise. During turning, care should be taken to avoid dust problem.

The windrows should be located over impervious surface so that the surface water from the windrows which may contain entrained particulates & pollutants is properly collected and safely disposed of after processing. Such process leachate can also be reused in composting operation.

The rejects from the process should be disposed off at properly designed and operated sanitary landfills. The MSW should be diverted to a properly operated sanitary landfill during annual maintenance period as well as during shutdown of the plant.

When the composting is carried out by controlling the various factors within the optimum range, proper quality compost will be obtained.

14.5.1 Properties of Compost

The compost prepared from MSW should be black brown or at least black in colour. It should be crumbly in nature with an earthy odour. The pH should be neutral though slightly acidic or alkaline pH within the range of 6.5 to 7.5 can be tolerated.

The compost should neither be completely dry nor it be lumpy and water should not come out of the mass when squeezed.

The Nitrogen, Phosphorous and Potassium (NPK) contents should be more than one percent each. The Nitrogen should be in the form of Nitrates for proper utilisation by the plants. The C/N ratio should be between 15 to 20.

In order to ensure safe application of compost, the standards laid down in the Draft on Municipal Waste (Management & Handling) Rules, 1999, notified on 27th September, 1999 by the Ministry of Environment & Forests, Government of India, for production of compost given as per table 14.3 must be adhered to:-

Table 14.3 Standards for Compost

Parameter	Maximum acceptable concentration parts per million (ppm)
Arsenic	20
Cadmium	20
Chromium	300
Copper	500
Lead	500
Mercury	10
Nickel	100
Zinc	2500

14.6 MECHANICAL COMPOSTING

Though manual methods are preferable in countries where labour is comparatively cheap, mechanical processes are preferred (Gotaas 1956) where higher labour costs and limitations of space exist. In 1922, Becari in Italy patented a process using a combination of aerobic and anaerobic decomposition in enclosed containers. The first full scale plant was established in 1932 in the Netherlands by a non profit utility company-VAM using Van Maanen Process in which raw refuse is composted in large windrows, which are turned at intervals by mobile cranes moving on rails. The Dano Process was developed in Denmark in 1930. Several other processes were subsequently developed using different methods of processing of solid waste using different designs of digester.

14.6.1 Unit Processes

A mechanical composting plant is a combination of various units which perform specific functions. Fig.14.3 gives a general flowchart of a mechanical compost plant.

Solid waste collected from various areas reaches the plant site at a variable rate depending upon the distance of collection point. As the compost plant operates at a constant rate, a balancing storage has to be provided to absorb the fluctuations in the waste input to the plant. This is provided in a storage hopper of 8 to 24 hours storage capacity, the exact value depending upon the schedule of incoming trucks, the number of shifts and the number of days the plant and solid waste collection system works.

The waste is then fed to a slowly moving (5metres/minute) conveyor belt and the non-decomposable material such as plastics, glass, metals are manually removed by labourers standing on either side of the conveyor belt. The labourers are provided with hand gloves and manually remove the material from the moving belt (the thickness over the belt is kept less than 15cms) and the removed material is stored separately.

The metals are then removed from the waste by either a suspended magnet system(Fig.14.4a) or a magnetic pulley system (Fig.14.4b). Majority of the metals are recycled at the source itself and hence are not contained in the waste. Magnetic removal of metals hence is not very efficient and therefore not used is India.

In developed countries glass and metals are present in larger concentration and are removed by using ballistic separators. In these units, the waste is thrown with a large force when different constituents take different tragectories and get separated (Fig.14.5). This unit is energy intensive and due to smaller content of glass and metals in Indian municipal solid waste, it is not used in India.

The waste is thus subjected to size reduction when the surface area per unit weight is increased for faster biological decomposition. Size reduction also helps in reducing fly breeding in the decomposing mass. This is commonly carried out either in Hammermills or Rasp mills. Hammermills are high speed (600-1200 revolutions per minute) compact machines but consume large energy (Fig.14.6). Rasp mills are slow moving large units that require lesser energy (Fig.14.7). The capital cost of a hammer mill is less but its operating cost is more than that of a rasp mill mainly due to the larger energy requirement as well as more frequent replacement / retipping of hammers.

The stabilisation is carried out in open windrows provided over flagstone paved or cement concrete paved ground. These windrows are turned every 5 days to ensure aerobic decomposition. Various types of equipment such as front end loaders/windrows reshifters are used for turning of windrows.

At the end of the 3 to 4 weeks period, the material is known as green or fresh compost wherein the cellulose has not been fully stabilised. It is hence stored in large sized windrows for 1-2 months either at the plant or the farms. At the end of the storage period, it is known as ripe compost. It may be sometimes subjected to size reduction to suit kitchen garden and horticulture requirements.

14.6.2 Experience in India

Ten mechanical compost plants were set up in India during 1975-80 under the Central Scheme of Solid Waste Disposal. These plants used different flowsheets. NEERI evaluated the performance of 7 of these mechanical composting plants during 1980-82. The studies revealed :-

- Large storage hoppers are not needed.
- The waste characteristics indicated that magnetic separators were inefficient at the concentration of metals in Indian municipal solid waste & need not be provided.
- Revolving drum mixers were counter productive and need not be provided.
- Covering of windrow area is not required as the plants are normally shut down during monsoon for annual repairs.
- Artificial aeration under Indian conditions does not reduce composting time and hence need not be provided.
- It is preferable to first stabilise the raw material and then subject it to picking and size reduction. This will require same windrow area, and improve efficiency of picking and size reduction.
- Composting should not be considered as a commercial venture but should be treated as a processing method and the sale price of compost fixed accordingly.
- In case the plants have to be set up by private agency, this aspect should be kept in view while entering into agreement.

14.6.3 Composting Plants for Indian Municipal Solid Waste

The Municipal Solid Waste in Indian urban centres has a favourable C/N ratio of around 30 and is amenable to composting. The farmers and horticulturists are also accustomed to the use of farmyard manure and hence may adopt compost prepared from municipal solid waste. While setting up a municipal scale mechanical compost plant the following steps need to be taken.

14.6.3.1 Assessment & Development of Market

The size and location of market for the sale of compost needs to be assessed through a market survey. The survey should assess the price which the consumer would be willing to pay and the transportation distance to the potential market. The demand of compost is seasonal and is dependent upon the crops being grown. Hence, the marketing and distribution system should include location of supply depots close to the bulk consumers.

14.6.3.2 Selection of Site

The site should be flat and should not be liable to flooding. It should be readily approachable but slightly away from a main road to avoid any nuisance to the traffic in the event of the plant not operating properly. The approach road should be sufficiently wide so that the traffic is not obstructed in the event of break down of incoming Municipal Solid Waste trucks. The areas where compost is to be supplied should be near the site and should be easily accessible. A site for disposal of non compostables should be available near the compost plant site.

Trees planted along the periphery of the site will serve partly as a barrier against the noise and odour from the plant and also help in litter control by reducing the wind speed . The trees will also protect the plant from dust and pollutants due to the highway.

14.6.3.3 Pilot Studies

The design and construction of a full scale compost plant needs at least 1.5 to 2 years. Before the plant becomes operational, pilot scale studies be carried out using a small quantity of the raw waste that will be used in the final plant. The raw waste as well as finished compost should also be analysed for heavy metal content. The output of the plant should be widely advertised to the consumers. The pilot studies will help determine the proportion of non-compostables that need disposal, the compost output per tonne of input and its nutrient contents.

The input to composting process should be carefully chosen to be mainly organic & should not contain any hazardous material. Wastes originating from industrial areas should have to be carefully selected to ensure that it does not contain any hazardous components.

The site should be properly paved and the run off from the area collected by a peripheral drain and taken to a sump from where it can be pumped and reused for tree plantation.

14.6.3.4 Flowsheet

In the pre-fermentation type of plant which are preferred, in a majority of Indian urban centres, the incoming trucks can directly discharge their contents in the windrow area.

During composting, the temperature of the mass has to be continuously monitored. This can be done by using probes. The optimum moisture content for composting is between 50-60%, while that in the incoming waste is much lower. The addition of moisture can hence be done through a hose connected to a fire hydrant. During composting, the moisture content tends to reduce and necessary moisture can be similarly added during turning.

After 20 days, the organic matter would be stabilised and the waste can then be taken for further processing.

The Indian waste characteristics indicate a low content of metals and glass. Further, when the recommendations of the committee appointed by Hon'ble Supreme Court regarding source separation are implemented, this proportion will be very small. Magnetic separators hence need not be provided. The glass, plastics and other inorganics can easily be removed using the manual separation process and ballistic separators will not be required. After pre-fermentation, the waste is transferred to a hopper using tractor trailor system. A conveyor at the bottom of the hopper transfers it to the sorting area where workers standing on either side of the conveyor belt remove the contraries and deposit them in bins placed alongside. As majority of Indian urban centres are not completely sewered, human excreta and cowdung are often mixed with the waste. After prefermentation, the material is no more offensive and hence does not pose any problem during manual separation.

The compost thus prepared can be sold directly to the farmers as raw or green compost. However, as the lignin content of the waste has not yet been stabilised, it should not be applied to the farms for at least two more months. In case adequate space is available at the plant, the material should be stored in large size maturation windrows for 2-3 months. During this period, lignin and other resistant material is stabilised and the product can then be sold as ripe compost.

In case the ripe compost is to be sold in bulk it can be sold as it is. Sometimes it is sold in small packets. In such cases, from marketing point of view, size reduction using a simple hammer mill is carried out and the material is bagged and sold. As the material is already stabilised, the required Horse Power of the hammer mill is less, thus reducing the energy consumption and maintenance problem.

In the North East Indian states, to protect the windrows from heavy rainfall, the windrow area will have to be covered. For urban centres in Kashmir and Himachal Pradesh covering of windrows will be necessary to protect the plant from low external temperatures.

14.6.3.5 Environmental Control

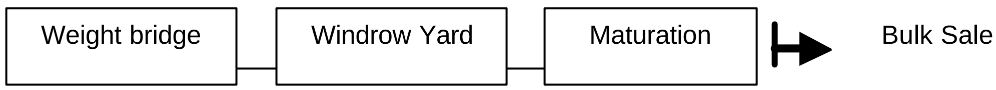
- All uncovered windrow areas should be provided with an impermeable base. Such a base may be made of concrete or of compacted clay, 50 centimetres thick, having permeability less than 10 centimetres/second. The base must be provided with 1 to 2 percent slope and must be encircled by lined drains for collection of leachate/surface water runoff. All lined drains should be connected to a lined settling pond, where tests for quality of waste-water are to be performed on a weekly basis. A treatment unit will be provided to ensure that the waste-water is discharged to open drains only after it meets the regulatory standards.

- On such days when the waste cannot be accepted at the compost plant or if shutdown occurs for extended period due to rains/cold climate/major breakdown or annual maintenance, the waste should be diverted to a properly designed and operated MSW landfill.

- The process rejects are to be removed from the compost plant on a daily basis. The recyclables should be diverted to appropriate vendors. The non-recyclables should be sent to a properly designed and operated MSW landfill. Temporary storage of rejects should be done in a covered area. If temporary storage is done in an open area, it must be done only for 1 or 2 days, at an area having an impermeable base and lined drains for collection of leachate/surface water runoff. The height of stockpiled waste should not exceed 3 metres and the storage area must have provision for odour control, litter control, fire control and birds control.

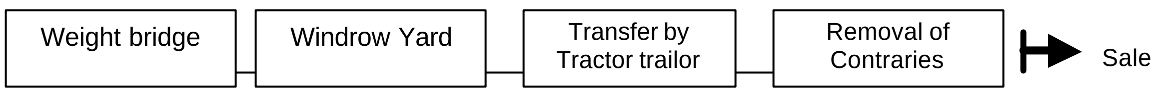
The general flowsheets for different population ranges are as given below :

I. Less than 1 Lakh population



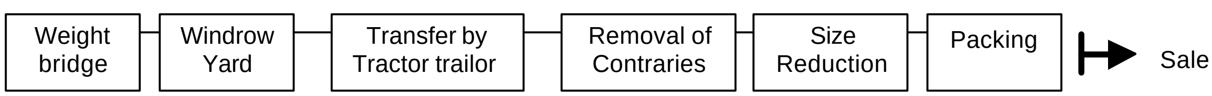
Manual Turning
every 5 days

II. Between 1,00,000 to 5,00,000 population



Turning by Front End Loader
every 5 days

III. More than 5,00,000 population



Turning by Front End Loader
every 5 days

CHAPTER 15
ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE

15.1 INTRODUCTION

Municipal Solid Waste (MSW) contains organic as well as inorganic matter. The latent energy present in its organic fraction can be recovered for gainful utilisation through adoption of suitable Waste Processing and Treatment technologies. The recovery of energy from wastes also offers a few additional benefits as follows:

(i) The total quantity of waste gets reduced by nearly 60% to over 90%, depending upon the waste composition and the adopted technology;

(ii) Demand for land, which is already scarce in cities, for landfilling is reduced;

(iii) The cost of transportation of waste to far-away landfill sites also gets reduced proportionately; and

(iv) Net reduction in environmental pollution.

It is, therefore, only logical that, while every effort should be made in the first place to minimise generation of waste materials and to recycle and reuse them to the extent feasible, **the option of Energy Recovery from Wastes be also duly examined.** Wherever feasible, this option should be incorporated in the over-all scheme of Waste Management.

15.2 BASIC TECHNIQUES OF ENERGY RECOVERY

Energy can be recovered from the organic fraction of waste (biodegradable as well as non-biodegradable) basically through two methods as follows:

(i) **Thermo-chemical conversion** : This process entails thermal de-composition of organic matter to produce either heat energy or fuel oil or gas; and

(ii) **Bio-chemical conversion:** This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol.

The Thermo-chemical conversion processes are useful for wastes containing high percentage of organic non-biodegradable matter and low moisture content.

The main technological options under this category include **Incineration and Pyrolysis/ Gasification.** The bio-chemical conversion processes, on the other hand, are preferred for wastes having high percentage of organic bio-degradable (putrescible) matter and high level of moisture/ water content, which aids microbial activity. The main technological options under this category is **Anaerobic Digestion,** also referred to as **Biomethanation**.

15.2.1 Parameters affecting Energy Recovery:

The main parameters which determine the potential of Recovery of Energy from Wastes (including MSW), are:

- Quantity of waste, and
- Physical and chemical characteristics (quality) of the waste.

The actual production of energy will depend upon specific treatment process employed, the selection of which is also critically dependent upon (apart from certain other factors described below) the above two parameters. Accurate information on the same, including % variations thereof with time (daily/ seasonal) is, therefore, of utmost importance.

The important **physical parameters** requiring consideration include:

- size of constituents
- density
- moisture content

Smaller size of the constituents aids in faster decomposition of the waste.

Wastes of the high density reflect a high proportion of biodegradable organic matter and moisture. Low density wastes, on the other hand, indicate a high proportion of paper, plastics and other combustibles.

High moisture content causes biodegradable waste fractions to decompose more rapidly than in dry conditions. It also makes the waste rather unsuitable for thermo-chemical conversion (incineration, pyrolysis/ gasification) for energy recovery as heat must first be supplied to remove moisture.

The important **chemical parameters** to be considered for determining the energy recovery potential and the suitability of waste treatment through bio-chemical or thermo-chemical conversion technologies include: -

- Volatile Solids
- Fixed Carbon content
- Inerts,
- Calorific Value
- C/N ratio (Carbon/Nitrogen ratio)
- toxicity

The desirable range of important waste parameters for technical viability of energy recovery through different treatment routes is given in the Table 15.1. The parameter values indicated therein only denote the desirable requirements for adoption of particular waste treatment method and do not necessarily pertain to wastes generated / collected and delivered at the waste treatment facility. In most cases the waste may need to be suitably *segregated/ processed/ mixed with suitable additives* at site before actual treatment to make it more compatible with the specific treatment method. This has to be assessed and ensured before hand. For example, in case of Anaerobic digestion, if the C/N ratio is less, high carbon content wastes (straw, paper etc.) may be added; if it is high, high nitrogen content wastes (sewage sludge, slaughter house waste etc.) may be added, to bring the C/N ratio within the desirable range.

Table 15.1 Desirable range of important waste parameters for technical viability of energy recovery:

Waste Treatment Method	Basic principle	Important Waste Parameters	Desirable Range*
Thermo-chemical conversion -Incineration -Pyrolysis -Gasification	Decomposition of organic matter by action of heat.	Moisture content Organic/ Volatile matter Fixed Carbon Total Inerts Calorific Value (Net Calorific Value)	< 45 % > 40 % < 15 % < 35 % >1200 k-cal/kg
Bio-chemical conversion	Decomposition of organic matter by microbial action.	Moisture content Organic /	>50 % > 40 %

-Anaerobic Digestion/ Bio-methanation		Volatile matter C/N ratio	 25-30

- Indicated values pertain to suitably segregated/ processed / mixed wastes and do not necessarily correspond to wastes as received at the treatment facility.

15.2.2 Assessment of Energy Recovery Potential

A rough assessment of the potential of recovery of energy from MSW through different treatment methods can be made from a knowledge of its calorific value and organic fraction, as under:

In thermo-chemical conversion all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output :

Total waste quantity : W tonnes
Net Calorific Value : NCV k-cal/kg.
Energy recovery potential (kWh) = NCV x W x 1000/860 = 1.16 x NCV x W
Power generation potential (kW) = 1.16 x NCV x W/ 24 = 0.048 x NCV x W
Conversion Efficiency = 25%
Net power generation potential (kW) = 0.012 x NCV x W
If NCV = 1200 k-cal/kg., then
Net power generation potential (kW) = 14.4 x W

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output :

Total waste quantity: W (tonnes)
Total Organic / Volatile Solids: VS = 50 %, say
Organic bio-degradable fraction : approx. 66% of VS = 0.33 x W
Typical digestion efficiency = 60 %
Typical bio-gas yield: B (m^3)= 0.80 m^3 / kg. of VS destroyed
= 0.80 x 0.60 x 0.33 x W x1000 = 158.4 x W
Calorific Value of bio-gas = 5000 kcal/m^3 (typical)
Energy recovery potential (kWh) = B x 5000 / 860 = 921 x W
Power generation potential (kW) = 921 x W/ 24 = 38.4 x W
Typical Conversion Efficiency = 30%
Net power generation potential (kW) = 11.5 x W

In general, 100 tonnes of raw MSW with 50-60% organic matter can generate about 1- 1.5 Mega Watt power, depending upon the waste characteristics.

15.3 TECHNOLOGICAL OPTIONS

There are various technological options which can be employed for recovery of energy from MSW (Fig. 15.1). While some of these have already been applied at a large scale, some others are under advanced stages of development. A brief on these technologies is given below.

15.3.1 Anaerobic Digestion (AD)

In this process, also referred to as bio-methanation, the organic fraction of wastes is segregated and fed to a closed container (biogas digester) where, under anaerobic conditions, the organic wastes undergo bio-degradation producing methane-rich biogas and effluent/ sludge. The biogas production ranges from 50-150m^3/tonne of wastes, depending upon the composition of waste. The biogas can be utilised either for cooking/ heating applications, or through dual fuel or gas engines or gas / steam turbines for generating motive power or electricity. The sludge from anaerobic digestion, after stabilisation, can be used as a soil conditioner, or even sold as manure depending upon its composition, which is determined mainly by the composition of the input waste.

Fundamentally, the anaerobic digestion process can be divided into three stages with three distinct physiological groups of micro-organisms:

Stage I: It involves the fermentative bacteria, which include anaerobic and facultative micro-organisms. Complex organic materials, carbohydrates, proteins and lipids are hydrolyzed and fermented into fatty acids, alcohol, carbon dioxide, hydrogen, ammonia and sulfides.

Stage II: In this stage the acetogenic bacteria consume these primary products and produce hydrogen, carbon dioxide and acetic acid.

Stage III: It utilizes two distinct types of methanogenic bacteria. The first reduces carbon dioxide to methane, and the second decarboxylates acetic acid to methane and carbon dioxide.

Factors, which influence the Anaerobic Digestion process, are temperature, pH (Hydrogen Ion Concentration), nutrient concentration, loading rate, toxic compounds and mixing. For start-up a good innoculum such as digested sludge is required. A temperature of about 35-38^{0}C is generally considered optimal in mesophilic zone (20-45^{0}C) and higher gas production can be obtained under thermophillic temperature in the range of 45-60^{0}C. Provision of appropriate heating arrangements and insulation may become necessary in some parts of the country.

Anaerobic Digestion (AD) of MSW offers certain clear advantages over the option of Aerobic process, in terms of energy production/ consumption, compost quality and net environmental gains:

(i) AD process results in net production of energy.

(ii) The quality of the digested sludge (compost) is better as Nitrogen is not lost by oxidation.

(iii) Its totally enclosed system prevents escape of polluted air to atmosphere.

(iv) The net environmental gains are positive.

15.3.1.1 Main Steps in Anaerobic Treatment of MSW

Pre-treatment: to remove inerts and non-biodegradable materials, upgrade and homogenise the feedstock for digestion and to promote downstream treatment processes.

Anaerobic Digestion: and to produce biogas for energy to de-odorise, stabilise and disinfect the feedstock.

Post-Treatment: to complete the stabilisation of the digested material and to produce a refined product of suitable moisture content, particle size and physical structure for the proposed end-use as organic manure.

Effluent Treatment: to treat the liquid effluent to specified standards before final disposal.

15.3.1.2 Different Designs and Configurations of AD Systems

Different designs and configurations of AD systems have been developed by various companies to suit different total solid concentration in the feed and microbial activity i.e. single phase, bi-phasic, multi-phasic. The more popular ones are broadly categorised as low/ medium and high solids, two phase and leach bed systems.

(i) Low / Medium Solid Digestion Systems:

A large number of systems presently available worldwide for digestion of solid wastes are for low (< 10%) or medium (10-16%) solid concentrations. Some of these systems, when applied to MSW or Market Waste, require the use of water, sewage sludge or manure.

(ii) High Solid Continuous Digestion Systems:

These systems have been developed since the late eighties principally for the organic fraction of municipal solid waste but have also been extended to other industrial, market and agricultural wastes. The digestion occurs at solid content of 16% to 40%. These systems are referred to as 'Dry Digestion' or Anaerobic Composting when the solid concentration is in the range of 25-40% and free water content is low. Systems in this category vary widely in design and include both completely mixed and plug-flow systems.

(iii) Two Stage Digestion Systems:

In these systems the hydrolysis, acidogenesis and acetogenesis of the waste are carried out separately from the methanogenesis stage. Since each step is optimised separately, so that each of the reactions (i.e. acidogenesis, methanogenesis, etc.) is operated closer to its optimum, the rate of digestion is significantly increased. However, requirement of two reactors and more process controls may lead to higher capital costs and system complications.

(iv) Dry Batch Digestion/ Leach Bed Process:

This design concept is closest to the processes occurring naturally in a landfill. The reactor containing the organic material is inoculated with previously digested waste from another reactor, sealed and allowed to digest naturally. The leachate from the bottom of the reactor is re-circulated and heated, if required, to promote the degradation process.

In Leach Bed systems also referred to as SEBAC systems (Sequential Batch Anaerobic Composting) this leachate is treated in a wastewater digester prior to recirculation, and thus the solid phase digester essentially acts like a hydrolysis / acid forming stage of a two phase system. This approach has the distinct advantage of reduced materials handling but overall degradation of the organic matter can be lower than other systems.

A great deal of experience with biomethanation systems already exists in India, but a large part of this is related to farm-scale biogas plants and industrial effluents. There is little experience in the treatment of solid organic waste, except sewage sludge and animal manure. However, several schemes for bio-methanation of MSW and Vegetable Market Yard Wastes, are currently planned for some cities of the country.

15.3.2 Landfill Gas Recovery

The waste deposited in a landfill gets subjected, over a period of time, to anaerobic conditions and its organic fraction gets slowly volatilized and decomposed according to the process similar to that taking place in an Anaerobic Digestion system as detailed in the previous section. This leads to production of landfill gas containing about 45-55% methane, which can be recovered through a network of gas collection pipes and utilised as a source of energy.

Typically, production of landfill gas starts within a few months after disposal of the wastes and generally lasts for about ten years or even more depending upon mainly the composition of wastes and availability / distribution of moisture. The yearly gas production rates observed in full size sanitary Landfills in other countries range from 5-40 litre/kilogram. The MSW generated in major Indian cities is rich in organic matter and has the potential to generate about 15-25 l/kg of gas per year over its operative period.

The proportion of various constituent gases changes with time since the onset of decomposition (Fig.15.2). The gas tends to escape through the cracks and crevices in the deposited material unless suitable outlet is provided. It also moves by diffusion (concentration gradient) and convection (pressure gradient) mechanisms. Such lateral migration poses danger to adjoining structures and vegetation.

This gas can be recovered through an active system of vertical or horizontal wells, which are drilled into the waste where methane is being produced. Vertical wells are the most common type used and are located at the rate of about two wells per acre. The wells normally consist of perforated High Density Poly Ethylene or Poly Vinyl Chloride pipes of 50 to 300mm diameter surrounded by 300mm thickness of 25-35 mm size gravel. The gas wells are provided at the time of

filling of the landfill. The schematic of a typical gas well is given in Fig.15.3 and that of a typical closed Landfill in Fig.15.4. Generally depth of the gas well is 80% of the height of landfill. The wells are connected by a main collection Header and the gas is pumped out under negative pressure by a blower. The gas is passed through a moisture trap, gas cleaning unit, (containing activated alumina, silica gel or molecular sieves) a flame arrester, a non-return valve and gate value before its connection to the compressor (Fig. 15.5). Usually several gas wells are connected to a blower, though pumping from all the wells is not carried out simultaneously. A flare (open / enclosed flame) is provided to burn the gas when it can not be used.

Some studies have indicated out that out of the total theoretical quantity of CH_4, 20-25% can be recovered. Studies carried out for a few Indian cities indicate that the gas will continue to be generated over a period of 7-10 years. The wells and the compressor can be designed for capacities based on these values.

Not all landfill gas generated in the landfill can be collected; some of it will escape through the cover of even the most tightly constructed and collection system. Newer systems may be more efficient than the average system in operation today. A reasonable assumption for the gas collection efficiency for a properly planned gas collection system is 70 - 85%.

At locations, where the gas recovery may not be feasible, passive venting may be required to be carried out, by using a perimeter trench filled with gravel or rubble enclosed in wire mesh.

Landfill gas has a calorific value of around 4500 Kilo Calories per Cubic metre . It can be used as a good source of energy, either for direct thermal applications or for power generation. There are three primary approaches to using the landfill gas:

(a) direct use of the gas locally (either on-site or nearby):

(b) generation of electricity and distribution through the power grid; and

(c) injection into a gas distribution grid.

Direct use of the gas locally is often the simplest and most cost-effective approach. The medium quality gas can be used in a wide variety of ways, including; residential use (cooking, hot water heating, space heating); boiler fuel for district heating; and various industrial uses requiring process heat or steam (such as in cement manufacture, glass manufacture, and stone drying).

A description of the different techniques involved in the utilisation of landfill gas for power generation is given under **Section 15.4.**

15.3.2.1 Selection of Existing Landfill Sites for Gas Recovery

Before proceeding with Gas Recovery projects, it is necessary to ascertain which of the existing landfills or open dumps are likely to be large enough to warrant attention. Generally the sites considered suitable for recovery of energy are those having over one million tonnes of waste in place, a majority of which should be less than ten years old. Such sites are expected to generate enough gas to support a profitable gas recovery project over a number of years.

15.3.2.2 Assessment of Gas Production Potential

The current end potential future amount of methane gas that can be produced/ collected from any landfill site depends upon several factors including the amount of waste in place and its characteristics. The steps involved in estimating the gas production potential are as follows:

(i) Estimation of Total Waste Landfilled:

An estimate of the waste quantity at individual landfills and open dumps can be made from a knowledge of the following:

- Area, Depth, and Waste Density.
- Waste Records.
- Contour Plots.

If this data is not readily available for urban areas, a rough assessment of waste in place can be determined using the following data:

- urban populations;
- waste generation rate per person per year;
- fraction of waste landfilled; and
- the number of years landfilling has been taking place.

Using this information, the total amount of waste placed in all the landfills and large open dumps in the urban area is calculated as following :

Total Waste Landfilled (tonnes) = Urban Population **x** Waste Generation Rate (kg/person/year) **x** Fraction of Waste in Landfills or Open Dumps **x** Years of Landfilling **x** 0.001.

The average waste quantity in place at each site can then be arrived at by dividing the above total quantity by the total number of the sites, and adjusted further in proportion to their relative areas and/ or depths.

(ii) Assessment of Waste Characteristics:

Waste characteristics influence both the amount and the extent of gas production within landfills. Different countries and regions have MSW with widely differing compositions; wastes from developing countries, are generally high in food and yard wastes, whereas developed countries, especially North America, have a very high paper and cardboard content in their MSW. Landfills in developing countries will tend to produce gas quickly (completing methane production within 10-15 years) because putrescible material decomposes rapidly. Landfills with high paper and cardboard content will tend to produce methane for 20 years or more, at a lower rate.

If hazardous materials are mixed with the MSW, the recovered gas may contain trace quantities of hazardous chemicals, which would need to be removed from the gas prior to utilization. Higher gas purification requirements translate to higher costs.

If landfills or large open dumps primarily have large quantities of construction and demolition debris, they will not produce expected quantity of gas. Therefore, these sites may not be good candidates for energy recovery.

A knowledge of the waste types contained in a landfill site is, therefore, very important for fair assessment of the gas production potential. However, waste disposal records are often incomplete or nonexistent and specific studies have to be conducted for each specific site to assess the waste composition.

(iii) Methods of Gas Production Potential:

The following three methods are commonly used to estimate the gas production:

(a) Test Wells:

The most reliable method for estimating gas quantity, short of installing a full collection system, is to drill test wells and measure the gas collected from these wells. To be effective, the wells must be placed in representative locations within the site. Individual tests are performed at each well to measure gas flow and gas quality. The number of wells required to predict the quantity of landfill gas will depend upon factors such as, landfill size and waste homogeneity.

A general rule applied is to reduce the amount of gas collected by test wells by 50%. This is done because wastes at these sites are often loosely compacted or spread in varying amounts across the landfill. Also, gas migration at these sites is a common problem, which can escalate the gas collection figures. Furthermore, reducing the test estimates to half provides a conservative estimate of gas production, which is important for purposes of determining the size of the energy recovery system. Later, if it is established that the gas is being under-utilized, it is easy to supplement the collection system; however, the reverse is not possible.

An added benefit of this method is that the collected gas can be tested for quality as well as quantity. The gas should be analyzed for methane content as well as hydrocarbon, sulfur, particulate, and nitrogen content. This will help in designing the processing and energy recovery system.

(b) Rough Approximation:

The simplest method of estimating the gas yield from a landfill site is to assume that each tonne of waste will produce 6 m^3 of landfill gas per year. The procedure for approximating gas production is derived from the ratio of waste quantity to gas flow observed in the many diverse projects already in operation. It reflects the average landfill that is supporting an energy recovery project, and may not accurately account for the quality of waste, climate, and other characteristics present at a specific landfill.

This rough approximation method only requires knowledge of how much waste is in place at the target landfill or large open dump. The waste tonnage should be less than ten years old. Estimates from this approximation may however vary by as much as 50%. This rate of production can be sustained for 5 to 15 years, depending on the site. The Rough Approximation method produces the lowest estimates of gas recovery. As such, it will be the most conservative estimate for purposes of conducting the site assessment.

(c) Model Estimates:

Although test wells provide real data on the site's gas production rate at a particular time, models of gas production predict gas generation during the site filling period and after closure. These models typically require the period of landfilling, the amount of waste in place, and the types of waste in place as the minimum data. Two main models used for emissions estimating purposes are the "First Order Decay Model" and the "Waste In Place Model". The First Order Decay Model produces the highest estimates, but its estimates are very sensitive to the assumptions made about the timing of the waste disposal and gas recovery.

15.3.3 Incineration

It is the process of direct burning of wastes in the presence of excess air (oxygen) at temperatures of about 800^0C and above, liberating heat energy, inert gases and ash. Net energy yield depends upon the density and composition of the waste; relative percentage of moisture and inert materials, which add to the heat loss; ignition temperature; size and shape of the constituents; design of the combustion system (fixed bed/ fluidised bed), etc. In practice, about 65 to 80 % of the energy content of the organic matter can be recovered as heat energy, which can be utilised either for direct thermal applications, or for producing power via steam turbine-generators (with typical conversion efficiency of about 30%).

The combustion temperatures of conventional incinerators fuelled only by wastes are about 760^{o} C in the furnace, , and in excess of 870^{o}C in the secondary combustion chamber. These temperatures are needed to avoid odour from incomplete combustion but are insufficient to burn or even melt glass. To avoid the deficiencies of conventional incinerators, some modern incinerators utilise higher temperatures of up to 1650^{o}C using supplementary fuel. These reduce waste volume by 97% and convert metal and glass to ash.

Wastes burned solely for volume reduction may not need any auxiliary fuel except for start-up. When the objective is steam production, supplementary fuel may have to be used with the pulverized refuse, because of the variable energy content of the waste or in the event that the quantity of waste available is insufficient.

While Incineration is extensively used as an important method of waste disposal, it is associated with some polluting discharges which are of environmental concern, although in varying degrees of severity. These can fortunately be effectively controlled by installing suitable pollution control devices and by suitable furnace construction and control of the combustion process. The various environmental concerns and pollution control measures are discussed in **Section 15.5**.

15.3.3.1 Basic Types of Incineration Plants

Both Stoker and Fluidised Bed type furnaces are used in incinerators. These are illustrated in Fig.15.6 and Fig.15.7. The modern municipal incinerators are usually of the continuously burning type, and may have “water wall” construction in the combustion chamber in place of the older, more common refractory lining. Corrosion of “water wall” units can, however, be a problem. Recent advancements include Twin Interchanging Fluidised Bed Combustor developed by a company in Japan, which is claimed to be capable of completely combusting wastes of low to high calorific values at very high overall efficiency (Fig.15.8).

Some basic types of Incineration Plants operating in the developed countries in the West and in Japan are as follows:

(i) Mass Burn:

About three-fourths of the waste-to-energy facilities in the U.S. and a few other countries are 'mass burn', where refuse is burned just as it is delivered to the plant, without processing or separation. These plants are sized to incinerate up to 3,000 tons of refuse per day and use two or more burners in a single plant. While facilities are sized according to the expected volume of waste, they are actually limited by the amount of heat produced when the garbage is burned. For example, if garbage burns hotter than it is expected to, less volume of material can be incinerated. Some mass burn plants remove metals from the ash for recycling. Mass burn plants have operated successfully in Europe for more than 100 years. A typical schematic diagram of such plants is given in Fig. 15.9.

(ii) Modular Combustion Units:

Modular incinerators are simply small 'mass burn' plants with capacity ranging from 25 to 300 tonnes per day. The boilers are built in a factory and shipped to the plant site, rather than being erected on the site, as is the case with larger plants. These facilities are often used in small communities.

(iii) Refuse-Derived Fuel (RDF) based Power Plants:

In an RDF plant, waste is processed before burning. Typically, the non-combustible items are removed, separating glass and metals for recycling.

The combustible waste is shredded into a smaller, more uniform particle size for burning. The RDF thus produced may be burned in boilers on-site, or it may be shipped to off-site boilers for energy conversion. If the RDF is to be used off-site, it is usually densified into **pellets** through the process of pelletisation.

Pelletisation involves segregation of the incoming waste into high and low calorific value materials and shredding them separately, to nearly uniform size. The different heaps of the shredded waste are then mixed together in suitable proportion and then solidified to produce **RDF pellets**. The calorific value of RDF pellets can be around 4000 kcal/ kg depending upon the percentage of organic matter in the waste, additives and binder materials used in the process, if any. Since pelletisation enriches the organic content of the waste through removal of inorganic materials and moisture, it can be very effective method for preparing an enriched fuel feed for other thermo-chemical processes like Pyrolysis/ Gasification, apart from Incineration. Additional advantage is that the pellets can be conveniently stored and transported.

RDF plants involve significantly more sorting and handling than Mass Burn facilities and therefore provide greater opportunity to remove environmentally harmful materials from the incoming waste prior to combustion. However, it is not possible to remove the harmful materials completely. Several years ago RDF was used mainly along with coal fired boilers but now, because of the stricter restrictions w.r.t. air emissions, it is usually burned in dedicated boilers designed and built specially for the RDF. In case of RDF Pellets too, it needs to be ensured that the pellets are not burned indiscriminately or in the open, but only in dedicated Incineration facilities or other well designed combustion systems, having all the necessary pollution control systems as described in **Section 15.5**.

15.3.3.2 Indian Scenario for Adoption of Incineration Technology

All sorts of waste materials are generated in the Indian cities as in other countries. However, in the absence of a well planned, scientific system of waste management (including waste segregation at source) and of any effective regulation and control of rag-picking, waste burning and waste recycling activity, the left-over waste at the dumping yards generally contains high percentage of inerts (>40%) and of puterscible organic matter (30-60%). It is common practice of adding the road sweepings to the dust bins. Papers and plastics are mostly picked up and only such fraction which is in an unrecoverable form, remains in the refuse. Paper normally constitutes 3-7% of refuse while the plastic, content is normally less than 1%. The calorific value on dry weight basis (High Calorific Value) varies between 800-1100 k-cal/kg. [**Tables 3.4 and 3.5 in Chapter 3**, refers]. Self sustaining combustion can not be obtained for such waste and auxiliary fuel will be required. Incineration, therefore, has not been preferred in India so far. The only incineration plant installed in the country at Timarpur, Delhi way back in the year 1990 has been lying inoperative due to mismatch between the available waste quality and plant design [The case study given in **Section 15.7** refers].

However, with the growing problems of waste management in the urban areas and the increasing awareness about the ill effects of the existing waste management practices on the public heath, the urgent need for improving the overall waste management system and adoption of advanced, scientific methods of waste disposal, including incineration, is imperative.

15.3.4Pyrolysis/ Gasification

Pyrolysis is also refered to as destructive distillation or carbonization. It is the process of thermal decomposition of organic matter at high temperature (about 900^0C) in an inert (oxygen deficient) atmosphere or vacuum, producing a mixture of combustible Carbon Monoxide, Methane, Hydrogen, Ethane [CO, CH_4, H_2, C_2H_6] and non-combustible Carbon Dioxide, water, Nitrogen [CO_2, H_2O, N_2] gases, pyroligenous liquid, chemicals and charcoal. The pyroligenous liquid has high heat value and is a feasible substitute of industrial fuel oil. Amount of each end-product depends on the chemical composition of the organic matter and operating conditions. Quantity and chemical composition of each product changes with pyrolysis temperature, residence time, pressure, feed stock and other variables.

Gasification involves thermal decomposition of organic matter at high temperatures in presence of limited amounts of air/ oxygen, producing mainly a mixture of combustible and non-combustible gas (carbon Monoxide, Hydrogen and Carbon Dioxide). This process is similar to Pyrolysis, involving some secondary/ different high temperature (>1000^oC) chemistry which improves the heating value of gaseous output and increases the gaseous yield (mainly combustible gases $CO+H_2$) and lesser quantity of other residues. The gas can be cooled, cleaned and then utilized in IC engines to generate electricity.

Pyrolysis/ Gasification is already a proven method for homogenous organic matter like wood, pulp etc. and is now being recognised as an attractive option for MSW also. In these processes, besides net energy recovery, proper destruction of the waste is also ensured. The products are easy to store and handle. These processes are therefore being increasingly favoured in place of incineration.

15.3.4.1 Different Types of Pyrolysis/ Gasification Systems

The salient features of different types of Pyrolysis/ Gasification Systems so far developed are given below.

(i) Garrets Flash Pyrolysis Process:

This low temperature pyrolysis process has been developed by Garrett Research and Development Company. In a 4 tonnes per day pilot plant set up by the company at La Varne, California, the solid waste is initially coarse shredded to less than 50mm size, air classified to separate organics / inerts and dried through an air drier. The organic portion is then screened, passed through a hammer mill to reduce the particle size to less than 3mm and then pyrolysed in a reactor at atmospheric pressure. The proprietary heat exchange system enables pyrolytic conversion of the solid waste to a viscous oil at 500^{0}C. A schematic diagram of this system is given in Fig. 15.10.

(ii) Pyrolysis Process developed by Energy Research Centre of Bureau of Mines, Pittsburg:

This is a high temperature pyrolysis process to produce both fuel oil and fuel gas and has been investigated mainly at laboratory scale. The waste charge is heated in a furnace with nickel-chromium resistors to the desired temperature. The produced gases are cooled in an air trap where tar and heavy oil condense out. Uncondensed vapours pass through a series of water-cooled condensers where additional oil and aqueous liquors are condensed. The gases are then scrubbed in an electrostatic precipitator before further use. It is claimed that one tonne of dried solid waste produces 300-500 m^3 of gas, but the process is yet to be tested at full scale. A schematic diagram of this system is given in Fig.15.11**.**

(iii) Destrugas Gasification System:

In this system (Fig. 15.12) the raw solid waste is first subjected to shredding / size reduction in an enclosed shed. The air from this shed is taken up as intake air in the plant so as to avoid odour problems. The shredded waste is fed to retorts (heated indirectly by burning gas in a chamber enveloping it) through which it sinks under gravity and gets subjected to thermal decomposition. The produced gas is washed and most of it (85%) used for heating the retorts. The remaining 15% is available as fuel. The slag consists of mostly char.

15.3.4.2 Other Emerging Processes

(i) Slurry Carb Process:

This process has been developed by a company in USA to convert municipal solid waste into fuel oil. It is used in conjunction with a wet resource recovery process to separate out the recyclables. The received waste is first shredded and placed in an industrial pulper. The heavier and denser inorganic material sink to the bottom of the water-filled pulper from where it is easily removed. The remaining waste slurry (organic fraction) is subjected to violent pulping action, which further reduces the size of its constituents. The pulped organic waste is then subjected to high pressure and temperature whereby it undergoes thermal decomposition / **carbonisation** (slow pyrolysis) to fuel oil.

(ii) Plasma Pyrolysis Vitrification (PPV) / Plasma Arc Process:

This is an emerging technology utilising thermal decomposition of organic wastes for energy / resource recovery. The system basically uses a Plasma Reactor which houses one or more Plasma Arc Torches which generate, by application of high voltage between two electrodes, a high voltage discharge and consequently an extremely high temperature environment (between 5000- 14,000^{o}C. This hot plasma zone dissociates the molecules in any organic material into the individual elemental atoms while all the inorganic materials are simultaneously melted into molten lava.

The waste material is directly loaded into vacuum in a holding tank, pre-heated and fitted to a furnace where the volatile matter is gasified and fed directly into the plasma arc generator where it is pre-heated electrically and then passed through the plasma arc dissociating it into elemental stages. The gas output after scrubbing comprises mainly of CO and H_2. The liquefied produce is mainly methanol.

The entire process is claimed to safely treat any type of hazardous or non-hazardous materials. It has the advantage that the NO_X (oxides of Nitrogen) and SO_X (oxides of Sulphur) gases emissions do not occur in normal operation due to the lack of oxygen in the system.

Some US companies offering PPV technology are reported to be setting up some demonstration units based on this technology in Malaysia and Singapore.

15.3.5 Advantages and Disadvantages of Different Technological Options

The main advantages and disadvantages of the different technological options described above are given in Table 15.2.

Table 15.2 Advantages and Disadvantages of Different Technological Options:

Advantages	Disadvantages
Anaerobic Digestion Energy recovery with production of high grade soil conditioner. No power requirement unlike aerobic composting, where sieving and turning of waste pile for supply of oxygen is necessary Enclosed system enables all the gas produced to be collected for use. Controls Green House Gases emissions Free from bad odour, rodent and fly menace, visible pollution and social resistance.	Heat released is less- resulting in lower and less effective destruction of pathogenic organisms than in aerobic composting. However, now thermophilic temperature systems are also available to take care of this. Unsuitable for wastes containing less organic matter Requires waste segregation for improving digestion efficiency.

Modular construction of plant and closed treatment needs less land area. Net positive environmental gains. Can be done at small-scale	
<u>Landfill Gas Recovery</u> Least cost option. The gas produced can be utilised for power generation or as domestic fuel for direct thermal applications.	Greatly polluted surface run-off during rainfall.
Highly skilled personnel not necessary. Natural resources are returned to soil and recycled. Can convert low lying marshy land to useful areas.	Soil / Groundwater acquifers may get contaminated by polluted leachate in the absence of proper leachate treatment system Inefficient gas recovery process yielding 30-40% of the total gas generation. Balance gas escapes to the atmosphere (significant source of two major Green House gases, carbon dioxide & methane) Large land area requirement Significant transportation costs to faraway landfill sites may upset viability Cost of pre-treatment to upgrade the gas to pipeline quality and leachate treatment may be significant. Spontaneous ignition/explosions due to possible build up of methane concentrations in atmosphere
<u>Incineration</u> Most suitable for high Calorific Value waste, pathological wastes, etc.	Least suitable for aqueous/ high moisture content/ low Calorific Value and

Units with continuous feed and high through-put can be set up. Thermal Energy recovery for direct heating or power generation. Relatively noiseless and odourless. Low land area requirement.	chlorinated waste . Excessive moisture and inert content affects net energy recovery; auxiliary fuel support may be required to sustain combustion Concern for toxic metals that may concentrate in ash, emission of particulates, SOx, NOx, chlorinated compounds, ranging from HCl to Dioxins
Can be located within city limits, reducing the cost of waste transportation. Hygienic.	High Capital and O&M costs. Skilled personnel required. for O&M. Overall efficiency low for small power stations .
Pyrolysis/ Gasification Production of fuel gas/oil, which can be used for a variety of applications Compared to incineration, control of atmospheric pollution can be dealt with in a superior way, in techno-economic sense.	Net energy recovery may suffer in case of wastes with excessive moisture. High viscosity of pyrolysis oil may be problematic for its transportation & burning.

15.3.5 Land Requirements

The area of land required for setting up any Waste Processing/Treatment facility generally depends upon the following factors:

- Total waste processing/treatment capacity, which will govern the overall plant design/size of various sub-systems.
- Waste quality/characteristics, which will determine the need for pre-processing, if required, to match with the plant design
- Waste treatment technology selected, which will determine the waste

fraction destroyed/converted to energy.

- Quantity and quality of reject waste, liquid effluents and air emissions, which will determine the need for disposal/post treatment requirements to meet EPC norms.

As such, the actual land area requirement can be worked out only in the Detailed Project Report for each specific project. However, for initial planning, the following figures may be considered for 300 TPD (input capacity) Waste-to-Energy facilities:

Incineration/Gasification/Pyrolysis plants	:	0.8 hectare*
Anaerobic Digestion Plants	:	2 hectares*
Sanitary Landfills (including Gas-to-Energy recovery)	:	36 hectares**

* Based upon typical installations

** For areas away from coast (can be more in coastal areas). This is estimated on the basis of a filling depth of 7m and Landfill life of 15 years.

15.4 UTILISATION OF BIO-GAS

Main constituents of biogas are Methane (about 60%), Carbon Dioxide (about 40%) and small quantities of Ammonia and Hydrogen Sulphide. The Calorific Value of biogas is about 5000 kcal/m^3 and depends upon the methane percentage. The gas from landfills generally has a lower calorific value.

The biogas, by virtue of its high calorific value, has tremendous potential to be used as fuel for power generation through either IC Engines or Gas Turbines can be utilised for this purpose.

15.4.1 Local Gas Use

The simplest and most cost-effective option for use of landfill gas/ biogas is local gas use. This option requires that the gas be transported, typically by a dedicated pipeline, from the point of collection to the point(s) of gas use. If possible, a single point of use is preferred so that pipeline construction and operation costs can be minimized.

Prior to transporting the gas to the user, the gas must be cleaned to some extent. condensate and particulates are removed through a series of filters and/or driers. Following this minimal level of gas cleaning, gas quality of 35 to 50 percent methane is typically produced. This level of methane concentration is generally acceptable for use in a wide variety of equipment, including boilers and engines. Although the gas use equipment is usually designed to handle natural gas that is nearly 100 percent methane, the equipment can usually be adjusted easily to handle the gas with the lower methane content.

15.4.2 Pipeline Injection

Pipeline injection may be a suitable option if no local gas user is available. If a pipeline carrying medium quality gas is nearby, only minimal gas processing may be needed to prepare the gas for injection. Pipe line injection requires that the gas be compressed to the pipeline pressure.

- **Medium Quality Gas**. Medium quality gas will typically have an energy value that is the equivalent to landfill gas with a 50% methane concentration. Prior to injection, the gas must be processed so that it is dry and free of corrosive impurities. The extent of gas compression and the distance required to reach the pipeline are the main factors affecting the attractiveness of this option.

- **High Quality Gas**. For high-quality gas, most of the carbon dioxide and trace impurities must be removed from the recovered gas. This is a more difficult and hence more expensive process than removing other contaminants. Technologies for enriching the gas include pressure swing adsorption with carbon molecular sieves, amine scrubbing, and membranes and are described in **Section 15.4.4.** The schematic of a typical gas filter system is shown in Fig. 15.13.

15.4.3 Electricity Generation

Electricity can be generated for on-site or for distribution through the local electric power grid. Internal combustion engines (ICs) and Gas turbines are the most commonly used for landfill gas/ biogas-to-power generation projects.

- **Internal Combustion Engines**. Internal combustion engines are the most commonly used conversion technology in landfill gas applications. They are stationary engines, similar to conventional automobile engines, that can use medium quality gas to generate electricity. While they can range from 30 to 2000 kilowatts (kW), IC engines associated with landfills typically have capacities of several hundred kW.

  IC engines are a proven and cost-effective technology. Their flexibility, especially for small generating capacities, makes them the only electricity generating option for smaller landfills. At the start of a recovery project, a number of IC engines may be employed; they may then be phased out or moved to alternative utilization sites, as gas production drops.

IC engines have proven to be reliable and effective generating devices. However, the use of landfill gas in IC engines can cause corrosion due to the impurities in landfill gas. Impurities may include chlorinated hydrocarbons that can react chemically under the extreme heat and pressure of an IC engine. In addition, IC engines are relatively inflexible with regard to the airfuel ratio, which fluctuates with landfill gas quality. Some IC engines also produce significant NO_x emissions, although designs exist to reduce NO_x emissions.

- **Gas Turbines**. Gas turbines can use medium quality gas to generate power of sale to nearby users or electricity supply companies, or for on-site use. Gas turbines typically require higher gas flows than IC engines in order to be economically attractive, and have therefore been used at larger landfills; they are available in sizes from 500 kW to 10 MW, but are most useful for landfills when they are 2 to 4 MW (USEPA, 1993c). Also, gas turbines have significant parasitic loads; when idle (not producing power), gas turbines consume approximately the same amount of fuel as when generating power. Additionally, the gas must be compressed prior to use in the turbine.
- **Steam turbines**: In cases where extremely large gas flows are available, steam turbines can be used for power generation.
- **Fuel cells:** Fuel Cells, an emerging technology, are being tested with landfill gas. These units, expected to be produced in the 1 to 2 MW capacity range, are highly efficient with relatively low NO_x emissions. They operate by converting chemical energy into usable electric and heat energy.

15.4.4 Purification of Biogas

Most effluents and solid wastes contain sulphates, which give rise to presence of H_2S in the biogas. The engines to be fuelled by biogas, can tolerate H_2S content of up to 1000 ppm, beyond which the H_2S can cause rapid corrosion.

Although biogas generated from MSW is generally not expected to contain high percentage of H_2S, adequate arrangements for cleaning of the gas have to be made in case it is beyond 1000 ppm. Systems being used to remove H_2S from biogas are based on Chemical, Bio-chemical processes or physical processes, which are described below:

15.4.4.1 Chemical Processes

Chemical processes are based on absorption of H_2S by Alkali, Iron or Amines. The most widely used process for desulphurisation is the Amine process because it selectively absorbs H_2S from biogas and can be carried out at near atmospheric pressure. This can reduce the H_2S content to 800 ppm. The raw biogas is treated through an absorber column against tri-ethanol amine solution. The absorber has one or more packing beds of polypropylene rings to provide better contact between gas and the liquid media. Amine solution while reacting with biogas, gets saturated with H_2S and CO_2 and is sent to the stripper column wherein it gets regenerated by stripping off the H_2S and CO_2 by heating with steam. The sour gases are let off to a chimney. The regenerated amine is ready for reuse.

15.4.4.2 Bio-chemical Processes

These processes uses secondary treated effluent to clean the biogas. This effluent is sprayed from the top of the absorber columns while the raw biogas is blown in from the bottom. The effluent cleans the biogas and is then sent to a aeration tank where the H_2S is converted into sulphates. The effluent from this aeration tank is partly supplemented by fresh treated effluent and partly disposed off. The formation of elemental sulphur is outside the scrubber and therefore ensures availability of the scrubber without choking effect.

15.4.4.3 Summary of Gas Cleaning Methods

A summary of the different methods being used for purification of biogas is given in Table 15.3.

Table 15.3 Summary of Gas Cleaning Methods

Compound	**Process type**	**Process alternatives available**
H_2O	Adsorption	1. Silica gel 2. Molecular sieves, and Alumina
	Absorption	1. Ethylene glycol (at low temperature -20°F) 2. Selexol
	Refrigeration	Chilling to -4°F
Hydrocarbons	Adsorption	Activated carbon
	Absorption	1. Lean oil Absorption 2. Ethylene glycol, and 3. Selexol (All at low temperatures of -20°F)
	Combination	Refrigeration with ethylene Glycol plus activated carbon Absorption
CO_2 and H_2S	Absorption	1. Organic solvents 2. Alkaline salt solutions 3. Alkanolamines
	Adsorption	1. Molecular sieves 2. Activated carbon
	Membrane separation	Hollow fiber membrane

	H_2S removal with Sulphur recovery	Bio-chemical process

15.5 ENVIRONMENTAL MANAGEMENT OF WASTE-TO-ENERGY PROJECTS

Any waste handling, treatment and disposal facility, either for energy/ resource recovery (including compost) or only for waste destruction, can be a source of environmental pollution (air/ ground/ water and land / visual/ noise/ odour pollution/ explosion), unless proper measures are taken in its design and operation. The major environmental concerns in case of the Waste-to-Energy facilities based on the established technologies of Incineration and Anaerobic Digestion, and the control measures necessary, are discussed in the next Section. The concerns/ measures for Incineration are, however, **generally also applicable** to the other waste processing/ treatment methods involving thermo-chemical treatment and those for Anaerobic Digestion, to the other waste processing/ treatment methods involving bio-chemical treatment (**including composting**).

15.5.1 Environmental Pollution Control (EPC) Measures for Incineration Plants

Incinerators burning MSW can produce a number of pollutants in the flue gas in varying concentration like carbon monoxide, sulfur dioxide, and particulate matter containing heavy metal compounds and dioxins. Many of these pollutants are formed as a result of incomplete/ partial combustion. That is, refuse that is not burned at high enough temperatures, for long enough or when too much or too little air has been added to the fire. The generation of these pollutants and their release into the atmosphere can be effectively reduced or prevented by incorporating a number of air pollution control devices and by proper operation of the WTE facility.

Concentrations of heavy metals in particulates, particularly lead, zinc, mercury and cadmium, may be significant and care must be exercised in their removal and disposal.

The most important of flue gas pollutants are sulphur dioxide (SO_2) and hydrogen chloride (HCl), the agents of acid rain. These may be eliminated by wet scrubbers. Hydrogen fluoride and oxides of nitrogen are also produced but are not normally a problem because of low concentrations. The emission of combustible, carbon-containing pollutants- dioxins and furans, is also of concern. The same can be controlled by optimizing the combustion process.

Other concerns related to incineration include the disposal of the liquid wastes from floor drainage, quench water, and scrubber effluents, and the problem of ash disposal in landfills because of heavy metal residues.

Following is a summary of the gaseous emission control devices now being used to remove pollutants from incinerator stack:

Dry Scrubbers

These "wash" particulate matter and gases from the air by passing them through a liquid. The scrubber removes acid gases by injecting a lime slurry (a watery mixture) into a reaction tower through which the gases flow. A dry powder containing salts is produced and collected alongwith the fly ash in an electrostatic precipitator or in filters and discharged alongwith the fly ash into the ash residue. The lime also causes small particles to stick together, forming larger particles that are easier to remove. Ash is stabilized by the addition of lime which enhances its natural alkalinity.

Electrostatic Precipitators (ESP)

These units use high voltage to negatively charge incoming dust particles, then the charged particles are collected on positively charged plates, ESPs - documented as removing 99.95% of Total Suspended Particulates (TSPs), including heavy metals - are very commonly used as WTE air pollution control devices. Nearly 43% of all existing facilities use this method to control air pollution.

Fabric Filters (Bag houses)

These consist of hundreds of long fabric bags made of heat-resistant material suspended in an enclosed housing which filters particles from the gas stream. Fabric filters are able to trap fine, inhalable particles (<10 microns) and can capture 99% of the particulates in the gas flow coming out of the scrubber, including condensed toxic organic and heavy metal compounds.

Stack Height

Stack height is an extra precaution taken to ensure that any remaining pollutants will not reach the ground in a concentrated area. When the gasses enter the stack they are quite clean due to the controls discussed above. Stacks being built today are 200-300 feet (60-90m)or more in height, twice as high as the stacks used on older municipal incinerators. Stack heights should be determined by calculating quantity of fuel used and considering local weather conditions also. Standard equations could be used for determining stack heights.

EPA, USA has developed strict air emission standards for incinerators. **CPCB has also stipulated certain standards for medical waste incinerators and these standards could be enforced till specific standards are evolved for MSW incinerators.**

The schematic of a typical flue-gas cleaning system of a modern MSW combustion facility is given in Fig. 15.14.

Dioxins and Furans:

In recent years, one group of chemical compounds, Polychlorinated dibenzofurans (PCDFs), commonly called dioxins and furans, has attracted special attention because of their toxicity, carcinogeecity and possible mutagenicity. These compounds are found in many foods - including fish, poultry and eggs - and occur in such common products as wood pulp and paper. About 75 different forms have been identified, of which five dioxins and seven furans are considered to be most toxic.

Fortunately, such compounds can be destroyed. It is claimed that by maintaining very high temperatures during the combustion process, waste-to-energy plants can eliminate virtually all of the dioxins that are produced. Also that a combination of scrubbers and fabric filtration systems can remove up to 99 percent of these large molecules. Activated carbon injection before the flue gas treatment has also proved to be effective. Activated carbon reactor and catalytic rectors can be used for advanced processing.

However, the dioxins and furans are the most controversial issues, and the mechanism of their production are not yet completely clarified and their removal methods are not yet completely established.

Water Pollution:

The liquid wastes of incineration - floor drainage, scrubber effluents and quench water - have the potential for the pollution of surface waters and aquifers, if they are discharged as waste effluents without treatment. **Faculty should make arrangements to meet the standards prescribed by the State Pollution Control Boards**.

Land Pollution:

Dry ash in the bottom residue and fly ash captured from flue gases in electrostatic precipitations or bag filters contain heavy metals and will pollute the land unless treated or disposed of at special hazardous waste landfills.

15.5.2 Environmental Pollution Control (EPC) Measures for Anaerobic Digestion Plants

The main points of concern relating to **Anaerobic Digestion** plants include:

- Biogas emissions/ leakage posing environmental and fire hazards.
- Gaseous exhaust from the power generating units which must be duly cleaned to meet specified standards for air emissions.
- Disposal of large quantities of water and of liquid sludge which can pose potential water pollution problem. While the liquid sludge can be used as rich organic manure, either directly or after drying, its quality needs to be duly ascertained for particular application. In case of use for food crops it needs to be to ensured that it is not contaminated by heavy metals/ toxic substances beyond permissible levels.

15.5.3 General Environmental Concerns and Control Measures

A summary of the general environmental concerns and control measures for waste processing, treatment and disposal facilities is given in Table 15.4.

15.6 PLANNING AND EXECUTION OF WASTE-TO-ENERGY PROJECTS

Any Waste-to-Energy project consist of several elements - collection/ availability of wastes, wastes treatment and recovery of energy, distribution and marketing of the end products, disposal of final rejects/ effluents, etc. If any of these elements malfunctions, smooth management of the project can not be ensured. A careful and proper advance planning is therefore very importance for the success of these projects.

Table 15.4 Summary of General Environmental Concerns and Control Measures for Waste Processing, Treatment and Disposal Facilities.

Waste treatment technology	Environmental concerns	Control measures

Thermo-chemical processes	Condensate from gas/ steam	Recovery, recycling in process/ treatment.
-do-	Residual inorganic material	Inert residual materials such as broken glass, crockery and rubble to landfill.
-do-	Gasifier char (a valuable source of plant nutrients). Incinerator ash	Leachability tests to determine soluble metal compounds. Contaminated char to be stabilised prior to disposal.
All power generation Facilities	Noise from gasifier and engines	To be enclosed in acoustic modules with noise attenuated to 75dB @ 1m from source. Plant to have adequate buffer space from nearest residential areas.
All incorporating wet separation processes	Contaminated water from separation process	Recovery, recycling in process/ treatment
All	Stormwater from site	If contaminated, diversion/storage for process use/ treatment to specified standard before discharge.
-do-	Wind blown rubbish	Mesh fences around facility with periodic cleaning of rubbish.
-do-	Odour from the waste storage / processing buildings	Air from these areas to be extracted and treated to destroy odour causing compounds prior to release to atmosphere.
-do-	Exhaust gas from combustion engines or	To be within limits prescribed by CPCB for industrial air

	process burners	emissions.
-do-	Flies and mosquitoes	All MSW received at the WTE site to be processed and disposed off within 10 hrs of their receipt.
-do-	Rats and Birds	MSW receival area to be cleaned daily. MSW storage area to be an enclosed/ sealed building and cleaned weekly.

15.6.1 Basic Factors in Planning and Execution

The important factors which need to be considered and taken into account while planning any Waste to Energy facility and for selecting most appropriate, techno-economically viable technology, are given below:

15.6.1.1 Cost of Collection & Transportation of Wastes

The logistics of waste collection/ segregation and its transport to plant site are of fundamental importance. Sufficient consideration should be given to the costs involved in the same. In the specific case of MSW, collection and transportation costs often account for the largest proportion of MSW treatment costs, which may be as high as 70% and may preclude consideration of certain technologies e.g. Sanitary Landfilling at faraway sites.

15.6.1.2 Scale of Treatment

The waste quantity available/ to be processed is another major factor requiring careful consideration. Large scale treatment would be advantageous for large cities where large waste quantities are discharged in limited area. Small scale treatment on the other hand may be more suitable for low discharge density/ small quantities of wastes to be treated. Such facilities will have the advantage that they can be operated easily and quickly. However, collection and transportation costs in this case (involving wide area) are bound to be higher than in the latter case involving a limited area, and a trade-off will be necessary.

15.6.1.3 Local Conditions/ Existing Waste Management Practices

The viability of any Waste to Energy Project, critically depends upon, inter-alia, an assured availability of the requisite quantities and quality of the waste. Implicit, therefore, will be the need to ensure proper linkages in waste management right from its generation at source to final disposal.

The waste management practices generally vary with: the local socio-economic and physical conditions, rates of waste generation, and wastes composition. The last two factors also determine the potential for energy recovery within the over all frame-work of the waste management system. The local socio-economic conditions and existing WM practices may, however, over-ride certain solutions which otherwise are techno-economically more viable. Conversely, there will be a need to improve the existing waste management practices/ local conditions to suit the selected technological option/ maximize energy recovery component.

For example, wastes of different qualities from different activities often get mixed up with the Urban Municipal waste stream. Some of these wastes have a very high percentage of organic matter and accordingly a high energy recovery potential. It should, therefore, be ensured that such wastes are collected and transported directly to the energy recovery facilities and not allowed to get mixed up with other waste streams with low energy recovery potential.

15.6.1.4 Physical and Chemical Characteristics of the Waste

A careful evaluation of percentage of bio-degradable/ combustible constituents/ moisture content of the waste and its chemical composition is necessary for selection of most appropriate technology.

Wastes from vegetable/ fruit yards and markets, agricultural and food processing units etc. contain high concentration of bio-degradable matter and are suitable for energy recovery through anaerobic de-composition. Solid wastes having a high proportion of paper and wood products, on the other hand, will be suitable for incineration.

The composite solid wastes in urban areas in India are characterized, in general, by low percentage of combustibles and high percentage of inorganic/ inerts and moisture and are not very suited for incineration. The waste is generally rich in bio-degradable matter and moisture content and can be treated anaerobically in Sanitary Landfills or Anaerobic Digesters for energy recovery.

In situations, where waste containing high percentage of combustibles and low percentage of inorganic/ inerts and moisture, is either available or can be ensured, through either adoption of effective waste segregation/ processing methods or in any other manner, the Incineration / Gasification / Pyrolysis options can be gainfully utilised.

15.6.1.5 Seasonal Fluctuations in Wastes Quantity & Quality

This is important as any imbalance between the availability of requisite quantity and quality of wastes and the energy demand/ utilization pattern may adversely affect the project's viability. In case of conversion to steam/ heat energy, it would be necessary to consume them in the vicinity of the plant as soon as produced. Otherwise, the technologies of transportable and storage type energy conversion viz. gasification/ pyrolysis (conversion to fuel oils), densification (conversion into fuel pellets) may be considered to tackle such imbalance.

15.6.1.6 Treatment/Disposal of Rejects/Effluents

The method of treatment and disposal of the final rejects/ effluents should be considered in advance. The utility of the same should also be considered as in case of anaerobic digestion, where about 70% of the input is discharged as sediment (digested sludge), but the same after being stabilized through aerobic treatment, can be used as a good fertilizer.

It should be borne in mind while adoption of any particular technology that MSW, though not classified as Hazardous or Toxic, may also contain some such waste component (solvents, paints, pesticides, sewage sludge, pathological wastes from hospitals, etc.). Proper Waste management requires that such waste materials are stored, collected, transported and disposed off separately, preferably after suitable treatment to render them innocuous and not mixed with the Urban Waste stream. The possibility, however, of Toxic & Hazardous wastes being present in the MSW, should be carefully examined and duly taken into consideration during their treatment/ processing and in the design of the WTE plants.

Plastic wastes may account for 1-10% of the total Municipal Solid Wastes. They are highly resistant to bio-degradation, which makes them objectionable for release to the environment and of special concern in waste management. Plastics have a high heating value making them very suitable for incineration. However, PVC when burnt, may, under certain conditions, produce dioxin and acid gas, which calls for adequate safety measures as already discussed in previous sections.

15.6.1.7 Energy End-Use

Effective marketability of end products (thermal energy/power/fuel oil/gas/pellets) will be a crucial factor determining the projects viability and needs to be tied-up in advance. In case of projects aimed at power generation, the availability of grid close to plant site would, of course, be necessary to enable wheeling of the generated power to third parties or its sale to utility.

15.6.1.8 Capital and Recurring Costs

These will be governed by, inter-alia, the Land area requirements and the auxiliary power/water requirements of the project besides availability of infrastructure and manpower with adequate expertise and skill for smooth operation and maintenance.

15.6.1.9 Environmental Impact

A relative assessment of different technological options from environmental angle is necessary keeping in view the existing regulatory standards. The basic approach adopted should be to promote environmentally sound waste disposal and treatment technologies and wherein energy recovery is only an additional benefit. **It should also be kept in view that a problem/ solution in waste disposal does not become a problem in air pollution or water pollution**.

In general, the ideal technology to choose should be the one which requires, per unit volume of the waste treated, the minimum space, generates the minimum rejects requiring further disposal and/ or effluents requiring least treatment before final usage on discharge, demands least O&M efforts on the part of user agency in terms of both O&M expenditure and manpower, has the best impact on minimizing environmental pollution, requires the least initial capital investment and, of course, recovers the maximum net energy. In practice, however, a trade-off between these aspects would have to be made and the decision based on techno-economic viability of any option at the specific site keeping in view the local conditions and the available physical and financial resources.

15.6.2 Scope of Feasibility Studies

The suggested scope of Feasibility Studies to be conducted for ascertaining the techno-economic viability of different waste treatment options is summarised below:

15.6.2.1 Quantity of Municipal Solid Waste Generated per day

- Per capita and total generation.
- Zone-wise quantity.

- Number of collection points along with quantity of waste available at each.

15.6.2.2 Current Mechanism for Collection/ Transportation

- Existing mode of collection
- Details of collection and dumping points, and waste quantities collected/ dumped per day at each point.
- Site maps showing the location of collection and disposal sites.

15.6.2.3 Physical & Chemical Characteristics of Collected Waste

- Size of constituents, density, moisture content, calorific value, ultimate/ proximate analysis, % of volatile solids & fixed carbon, etc.
- Sampling of waste to be over minimum period of 3 consequtive seasons.
- Sampling procedure to be as per BIS norms.

15.6.2.4 Present Mode of Disposal

- Burning/ composting/ other methods.
- Expenditure involved.

15.6.2.5 Provisions in the Existing System for

- Segregation of inert material
- Recycling
- Scientific disposal/ energy recovery
- Revenue generation

15.6.2.6 Commitments/Arrangements of Concerned Municipality with Private Parties regarding Waste Collection/ Disposal , if any

15.6.2.7 Details About the Proposed Scheme of Energy Recovery

- site details / suitability
- sizing of plant capacity
- estimated waste processing/ treatment capacity

- estimated energy recovery potential/ other by-products.
- assessment of alternative options/ technology selection;
- quantity & quality of final rejects to be disposed off & their disposal method;

15.6.2.8 Environmental Impact Assessment Analysis of the Selected Option

15.6.2.9 Energy End-Use & Revenue Generation

15.6.2.10 Cost Estimates

Capital cost, O&M costs including manpower,

Revenue, Cost benefit analysis, etc.

15.7 CASE STUDIES

Some Case Studies on specific projects on Energy Recovery from Municipal Solid Wastes in developed countries as well as India, are cited in the Annexure 15.1 to provide a brief over-view of the developments in the *Waste-to- Energy* sector across the world.

15.8 CONCLUSIONS

The different technologies for recovering useful energy from Municipal Solid Wastes already exist and are being extensively utilised in different countries for their multiple benefits. It is necessary for the success of these technologies in India to evolve an Integrated Waste Management system, coupled with necessary legislative and control measures. A detailed feasibility study needs to be conducted in each case, duly taking into account the available waste quantities and characteristics and the local conditions as well as relative assessment of the different waste disposal options. Suitable safeguards and pollution control measures further need to be incorporated in the design of each facility to fully comply with the environmental regulations and safeguard public heath. The Waste-to-Energy facilities, when set up with such consideration, can effectively bridge the gap between waste recycling, composting and landfilling, for tackling the increasing problems of waste disposal in the urban areas, in an environmentally benign manner, besides augmenting power generation in the country. Ministry of Non-Conventional Energy Sources is providing financial assistance for energy recovery projects given as per Annexure 15.2.

ANNEXURE – 15.1

Waste-to-Energy Case Studies

1. Puente Hills Landfill, Los Angeles County, California, USA:

Puente Hill landfill is owned and operated by the Sanitation Districts of Los Angles County. It encompasses an area of 1,365 acres, only half of which is ear-marked for use as landfill. The entire site is being developed, in cooperation with the County Department of Parks and Recreation, into recreational facilities to benefit the surrounding Communities.

The land fill receives 12,000 tons of waste per day Part of the landfill is already closed and producing 27000-28000 CFM gas with typical composition of 36-40% methane, 35% CO_2, 5% O_2 and 90-100 ppm H_2S. The gas collected from the landfill is delivered to the Puente Hills Energy Recovery Facility, where it is burned in a boiler to produce steam which is fed to a turbine generator set (two steam boilers each of the rating of 264,000 lb/hr at 1000^o F and one turbine of 1850 lb/hr.). The power generation is close to 50 MW which makes it the largest Landfill Gas to Energy Facility in the world.

The landfill started commercial production of power from Jan.1, 1987. The complete power plant was financed by the Banks and the plant has repaid all the money within first 5 years of its operation. The total cost of the project including interest which was repaid to bank was nearly US$ 35 mln.. During 1st year of operation i.e. 1987 the company charged 12 cents/kwh from the grid. The charge was 15 cents/kW-hr during 1996, the last year of the initial 10 year agreement. As per the new agreement subsequently entered, the company is selling power to the grid at 8 cents/ kW-hr.

The Operations Report of the Energy Recovery Facility for the month of March 1997 was as under :

Gross Power	37,766,000	kW-hr
Parastic Power	2,832,000	kW-hr
Net Power	34,934,000	kW-hr
Net average	47,000	kW
Average LFG used	23,800	SCFM
Availability	100.0	%
Capacity Factor	101.5	%
Dispenser Availability	100.0	%
‘Solar’ on line	87.0	%

The net energy generation and total income during the years 1993 - 96 has been as under:

Year	**Total Income ($)**	**Total Net kW-hr (approx)**
1993	49219330	394 MU
1994	52445031	394 MU
1995	56276480	397 MU
1996	60235255	408 MU

No manure is being sold at present but the same is planned in near future.

The company also has a CNG facility producing 100 cfm of high quality CNG containing on an average 97.5% methane. In this facility Methane gas coming from landfill is dewatered, purified by membrane purification technology which requires minimal maintenance, and pressurised to produce high quality CNG. The total project cost of this component was approximately US$ 1 million. The facility is projected to be capable of producing clean fuel at an equivalent gasoline cost in the range of US$ 0.5-1.0 per gallon.

The tipping fee charged by the company was US$8/tonne in 1988, US$18 to US$26/tonne in 1995 and is presently US$ 26/ton.

The Puente Hill Landfill has the capacity to provide environmentally sound disposal for the residents and business of Los Angeles county until the year 2013.

2 Belrose Power Plant:

Project Location	Belrose, New South Wales, Australia
Power Generation Capacity	4 MW
Fuel	Landfill Gas
Power Purchaser	Energy Australia
Start of Operation	1995

Landfill gas is extracted from the landfill site, processed to remove moisture and particulate matter and utilised as fuel for power generation. The power produced is supplied to the utility distribution system.

The gas extraction system comprises gas production wells drilled into the landfill. The wells are fitted with wellheads comprising valves and flow meters to control the flow from each well. An underground pipeline network connects the wells to a central gas compression and processing plant. Gas is produced at approximately 50% methane content. Gas blowers maintain vacuum on the gas extraction system and compress the gas to the pressure required for supply to the generating plant.

The generating plant comprises four gas engine generator sets. Generation voltage is 415volts which is stepped up by the unit transformers for each generator set, to 33KV at which it is electrically interconnected with the utility distribution system.

3 The Tiburg Plant (The Netherlands):

The plant based on biomethanation was built in 1993 for the processing of 52000 tons/ year of source-sorted organic fraction of municipal solid waste known as Vegetable Garden and Fruit Waste. The salient features of the plant are as follows:

Treatment capacity	52 000 t/y VGF
Digester volume	2 x 3 300 m^3
Waste composition	46% TS - 45% VS
Retention time	20 days minimum
Biogas production	80-85 Nm^3 / ton feed in digester
Specific methane yield*	220 - 250 Nm^3 /ton VS fed in digester
Biogas end-use	Injection into the gas network after purification.

Compost Characteristics:

Heavy metals	mg/ kg TS
	Cd = 0.5
	Hg = 0.1
	Pb = 67.0
	Se = 5.0
	Cu = 23.0
	NI = 7.6
	Zn = 190.0
Salmonella	absence on 25 g.

**after storage and screening.*

4 The Amiens Plant (France):

The plant was built in 1987 for the processing of 55,000 tons/ year of Amiens municipal solid waste. A mechanical sorting unit allows for the separation of the organic fraction from MSW.

In 1996, as the process was considered fully reliable and economical by the other municipalities in the district of Amiens, the treatment capacity was extended to 85,000 tons/ year with the construction of an additional digester. Details of the plant are as follows:

Treatment capacity	85000t/y MSW
Digester volume	3 x 2 400 m^3 (start-up in 1988) 1 x 2 500 m^3 (start-up in 1996)
Sorted Waste composition	60% TS - 63% VS
Retention time	18 - 22 days
Biogas production	140 - 160 Nm^3 / ton fed in digester
Specific methane yield	220 - 250 Nm^3 /ton VS fed in digester
Biogas end -use	high pressure steam for industrial consumption purpose - (5500 kW)

5 Chitose Incineration Plant (Metropolitan Tokyo):

Capable of handling up to 600 tons of garbage per day, the Chitose Incineration Plant is Japan's largest urban incinerator. Because the plant is situated in a residential area, the most pressing concerns in its design were pollution and an appealing external appearance. The Kumagai Gumi facility is innovative both in terms of its technology, design and building arrangement. Because all operations are computer controlled, the facility's construction required accuracy down to the millimeter. Moreover, electricity generated by heat from the incinerator provides all the plant's electricity requirements. All in all, the state-of-the-art plant is at the vanguard of waste disposal in Japan.

Owner	Tokyo Metropolitan Government
Design	Kumagai Gumi Co., Ltd.
Structure	Steel reinforced concrete 7/3
Area	20,998 square meters
Height	130 meters
Smokestaack	Reinforced concrete

6 Refuse Incineration cum Power Generation Plant, Timarpur, Delhi:

This R&D/ Pilot Plant for incineration of municipal solid waste of Delhi city and generation of power as a by-product, was set up in the year 1987 with assistance from Government of Denmark..

Location	Timarpur, Delhi
Year of installation	1987
Feed-stock Incineration capacity	300 TPD Municipal Solid Waste Net Calorific Value (NCV) : 1462.5 k-cal/kg. (for rated power output)
Rated Power Generation Capacity	3.75 MW
Technology	Incineration
Capital Cost	Rs. 25 crore (approx.)
Supplier of Technology/ Turn-key contractor	M/s Volund Miljotecknik A/S, Denmark

The plant was on trial run and was operated for a few months and was subsequently closed down in the year 1990 due to mismatch of quality of incoming Refuse (MSW) with the plant design.

The up-keep and shutdown maintenance of the plant is continuously being carried out through the Delhi Vidyut Board, till the plant assets are put to an alternative / effective use.

A possibility is being explored to lease out the entire facility, on 'as is where is basis' to entrepreneurs interested in taking over the plant and making their own investment to carry out necessary modifications or additions to the plant and for operating it on commercial basis.

7. Waste Recycling Park, Wels, Austria:

The Wels Waste Recycling Park is a modern waste processing & disposal facility set up in 1995 for integrated waste management. It is owned by a consortium of the County, the Municipality, the Utility and the Plant Operating Company/Electricity supplier- M/s Welser Abfallverwertung, G.m.b.H.

The total processing capacity of the plant is 160,000 tonnes per annum (TPA) of different waste streams :

25,000 TPA	organic waste
30,000 TPA	industrial waste
60,000 TPA	construction sites waste
45,000 TPA	households waste
160,000 TPA	

The plant handles these wastes through different processing routes depending on their nature:

(i) 60,000 TPA waste from households and other sources is of combustible nature and is combusted in an Incineration Plant which generates 7 MW power. The captive consumption is 1.5 mw and the rest is exported to grid, corresponding to an annual energy production of 36 MU. The facility has a 63 m high chimney and has the most modern treatment system for emission control and also for Ash Treatment, and which accounts for a major position of the total plant cost of 980 mln. Shillings. It comprises of ESPs, Wet scrubbers, Activated Carbon Filter, Catalytic Converter. The emission levels achieved are understandably the best in the world and are as under :

Dust	8	mg/m^3	C(org)	8	mg/m^3
HCl	7	,,	Col	0.05	,,
HF	0.3	,,	Hg	0.05	,,
SO_2	20	,,	Dioxin	0.1	ng/m^3
NO_x	100	,,			
CO	50	,,			

(ii) 25000 TPA of Industrial waste is fed to a sorting station. 20,000 TPA of the sorted waste goes to the Incineration plant and the remaining 5000 TPA to far-away Landfill site.

(iii) 19000 TPA of Organic Waste comprising Sewage sludge and other compostibles is processed in a Anaerobic Treatment Plant. It incorporates various steps - shredding, iron separation, slurry formation, Anaerobic Digester, Gas Holder, Cogeneration Power plant. The waste sludge from the reactor is dried by a centrifuge and fed to an Aerobic composting/treatment unit alongwith some other incoming wastes (not treated anaerobically).

The Anaerobic digester has a capacity of $1600m^3$ and produces 1 $mln.m^3$ gas ($6m^3$ per MT per day) . The cost of the AD system is stated to be 100 mln. Shillings. The final compost (9000 TPA) is transported to a far-away Landfill site, and not used or considered suitable as fertiliser .

(iv) 6000 TPA construction waste is fed to a treatment section and most of it is transferred therefrom to far-away Landfill site. About 1000 TPA is combustible and transferred to the Incineration plant. The entire facility is very impressive and is an excellent combination of the latest waste treatment technologies which dispose of nearly 90% of the waste received, and with remarkable environmental pollution control.

CHAPTER 16

EMERGING PROCESSING TECHNOLOGIES

16.1 INTRODUCTION

Besides the established techniques such as composting, incineration, etc. (chapters 14 & 15), various new methods are being developed for processing of municipal solid waste. All these methods reduce the pollution potential & quantity of solid waste requiring to be disposed off and also sometimes result in recovery of some by products having potential use.

These processes commonly follow either the biological or the thermal route. However, a few methods use a combination of these routes while others which treat the waste as an ore etc. have been developed in the developed countries but their suitability for the Indian municipal solid waste has not yet been established are discussed in this chapter.

16.2 VERMICOMPOSTING

Vermicomposting involves the stabilisation of organic solid waste through earthworm consumption which converts the material into worm castings. Vermicomposting is the result of combined activity of microorganisms and earthworms. Microbial decomposition of biodegradable organic matter occurs through extracellular enzymatic activities (primary decomposition) whereas decomposition in earthworm occurs in alimentary tract by microorganisms inhabiting the gut (secondary decomposition). Microbes such as fungi, actinomycetes, protozoa etc. are reported to inhabit the gut of earthworms. Ingested feed substrates are subjected to grinding in the anterior part of the worms gut (gizzard) resulting in particle size reduction. Vermitechnology, a tripartite system which involves biomass, microbes and earthworms in influenced by the abiotic factors such as temperature, moisture, aeration etc. Microbial ecology changes according to change of abiotic factors in the biomass but decomposition never ceases. Conditions unfavourable to aerobic decomposition result in mortality of earthworms and subsequently no vermicomposting occurs. Hence, preprocessing of the waste as well as providing favourable environmental condition is necessary for vermicomposting.

The vermicompost is relatively more stabilised and harmonises with soil system without any ill effects. Unfavourable conditions such as particle size of biomass and extent of its decomposition, very large temperature increase, anaerobic condition, toxicity of decomposition products etc. influence activity of worms.

This technology has been used for agricultural waste and its adoption to municipal solid waste is of recent origin.

The worm species that are commonly considered are **Pheretima sp, Eisenia sp & Perionyx excavatus sp.** These worms are known to survive in the moisture range of 20-80% and the temperature range of 20-40^{o}C. The worms do not survive in pure organic substrates containing more that 40% fermentable organic substances. Hence fresh waste is commonly mixed with partially or fully stabilised waste before it is subjected to vermicomposting. The worms are also known to be adversely affected by high concentrations of such heavy metals, as Cd (Cadmium), Cr (Chromium), Pb(Lead) & Zn(Zinc). Due to the constraints of the temperature, moisture, Fermentable Organic Substances (FOS) and heavy metals use of vermicomposting on municipal scale has not been successful. However, use of this method for wastes from individual houses, housing colonies etc. where the waste is mainly organic in nature and where the quantities are less and can be manually handled is common.

Table 16.1 indicates the chemical analysis of earthworm casting from soil and soil mixed with cowdung.

Table 16.1 Chemical analysis of earthworm casting

Casting Source	Total Nitrogen (%)	Nitrate	Total Phosphorus (P)	Water Soluble (P)	Total Potassium	Water Soluble Potassium
Soil	0.18	0.40	732	6.00	84.00	4.0
Cowdung + Soil	0.38	25.00	521	2.00	37.21	88.0

Values, except total nitrogen are in milligram (mg)/100 gram (gm).

16.3 BIOGAS FROM MUNICIPAL SOLID WASTES

When municipal solid wastes with a large proportion of organic matter is subjected to anaerobic decomposition, a gaseous mixture of Methane & Carbon di-oxide (CH_4 & CO_2) known as biogas could be produced under favourable conditions. The process is quite stable and upsets do not easily occur. The gas production ranges from 0.29 m^3 /kg of VS added/day to 0.16 cubic metre (m^3)/kilogram of VS added/day in different seasons. The pH (Hydrogen Ion Concentration) of the digesting mixture remains around 6.8 $\pm$ 0.20.

The volatile solids destruction ranges from 40 to 55%. The sludge has good manurial value of Nitrogen, Phosphorous, Potassium (NPK :: 1.6 : 0.85 : 0.93) and is observed to drain easily. The process gives a good performance at a detention time of 25 days.

A large number of plants to stabilise organic waste from vegetable market solid waste to biogas have been operating in Europe and United States of America. These plants mainly use low solids digestion or high solids digestion in single stage or multistage processes. The Steinmuller Valorga process and Dranco process are reported to have a favourable cost benefit ratio. (Additional details of these plants are provided in Chapter 15).

Presently no such plants exist in India. However, proposals to construct two such plants with Ministry of Non Conventional Energy Sources funding, to process market waste are in an advanced stage of consideration.

16.4 CONVERSION OF SOLID WASTES TO PROTEIN

Laboratory investigations conducted at Louisana State University, USA showed that under aerobic conditions, it is possible to convert the insoluble cellulose contained in municipal waste by a cellulytic bacteria. The bacteria are then harvested from the media for use as protein. Studies were conducted using waste bagasse as the sole carbon source. The process involves size reduction followed by a mild alkaline oxidation treatment before aerobic oxidation. The bagasse is slurried in water, mixed with simple nutrient salts mixture and then fed to the reactor from where it is harvested. The single cell protein produced has a crude protein content of 50 to 60%. It has a good amino acid pattern and has been successfully tested on animals. The process has yet to be tested on a full scale basis, but shows promise, especially due to its high efficiency of protein production. It has been shown that a 450 kg bullock can synthesize 0.4 kg of protein in every 24 hours (hrs) whereas 450 kg of soyabean synthesizes 36 kgs protein in 24 hrs and 450 kg of yeast can synthesize more than 50 tonnes of protein in 24 hrs.

16.5 ALCOHOL FERMENTATION

This is a developing technology applicable to cellulosic biomass. It involves anaerobic decomposition of cellulosic organic matter by Ethanologic bacteria to produce mainly Ethanol.

More than 95% of the Ethanol produced world-wide is through fermentation by yeast of molasses or starch (sugar or starch substances) which are in short supply and are required for alternative uses. Ethanol production utilising less expensive, abundant and renewable feed-stock such as cellulosic bio-mass (lignocellulosics) is, therefore, desirable. Yeasts, however, are currently unable to degrade cellulose. Acid/Alkali treatment of ligno-cellulosics removes lignin & other inhibitory materials and renders the biopolymers accessible to enzymatic degradation and Ethanol production. This is, however, an extra cost factor.

Bacterial strains have been developed in recent years which yield high substrate conversion efficiencies and Ethanol tolerance. Some of these bacteria also have the ability to ferment both cellulose and hemi-cellulose leading to complete utilisation of cellulosic bio-mass. Such production of Ethanol has a great potential and is one of the best eco-friendly technologies for energy recovery from fibrous wastes. Ethanol can be used as a fuel, a fuel additive, or as a chemical feed stock.

16.6 PYROLYSIS

Pyrolysis involves an irreversible chemical change brought about by the action of heat in an atmosphere devoid of oxygen. Synonymous terms are thermal decomposition, destructive distillation and carbonisation. In partial combustion, oxygen is present in insufficient quantities to cause complete combustion (i.e., less than SOR). Normal combustion, as in conventional incineration requires the presence of sufficient amount of oxygen which will ensure complete oxidation of organic matter. Using cellulose ($C^6\ H^{10}\ O^5$) to represent organic matter, the reaction is

$$C_6H_{10}O_5 + 6O_2 \longrightarrow 6CO_2 + 5H_2O + \text{heat} \quad (H_2O : \text{Water})$$

$$(CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{heat})$$

To ensure complete combustion and to remove the heat produced during the reaction, excess air is supplied during incineration which leads to air pollution problems.

In the case of partial combustion, the reaction would be

$$2\,CH_4 + O_2 \longrightarrow 2CO + 4H_2$$ (CO : Carbon Monoxide
H_2 : Hydrogen)

$$CO + H_2 \longrightarrow HCHO$$ (formaldehyde)

$$CO + 2H_2 \longrightarrow CH_3\,OH$$ (methanol)

Thus even the simplest of hydrocarbons will yield a variety of products under conditions of partial combustion. As the complexity of fuel increases the variety of possible products also increases. Pyrolysis, unlike incineration is an endothermic reaction and heat must be applied to the waste to distill off volatile components.

When the waste is predominantly cellulose under slow heating at a moderate temperature, the destruction of bonds is selective (the weakest breaking first) and the products are primarily a non-combustible gas and a non-reactive char. On the other hand, when the waste is rapidly heated to a high temperature, complete destruction of the molecule is likely to take place. Under intermediate conditions, the system would yield more liquid of complex chemical composition. Normally these two processes are referred to as **low temperature and high temperature pyrolysis respectively**. Pyrolysis is carried out at temperature between 500 and 1000^{O}C to produce three component streams.

i)	Gas	:	It is a mixture of combustible gases such as hydrogen, carbon monoxide, methane, carbon dioxide and some hydrocarbons.
ii)	Liquid	:	It contains tar, pitch, light oil and low boiling organic chemicals like acetic acid, acetone, methanol, etc.
iii)	Char	:	It consists of elemental carbon along with the inert materials in the waste feed.

The char, liquids and gas have a large calorific value. This calorific value should be utilised by combustion. Part of the heat obtained by combustion of either char or gas is often used as process heat for the endothermic pyrolysis reaction. It has been observed that even after supplying the heat necessary for pyrolysis, certain amount of excess heat still remains which can be commercially exploited. Though a number of laboratory & pilot investigations have been made, only a few have led to full scale plants. Details of such plants are given in Chapter 15.

16.6.1 Plasma Arc Technology/Plasma Pyrolysis Vitrification (PPV)

This is an emerging technology for energy/resources recovery from organic wastes. The system basically uses a Plasma Reactor which houses one or more Plasma Arc Torches which generate, by application of high voltage between two electrodes, a high voltage discharge and consequently an extremely high temperature environment (between 5000-14,000^{o}) approximating the temperature of the Sun. This hot plasma zone dissociates the molecules in any organic material into the individual elemental atoms while all the inorganic materials are simultaneously melted into a molten lava.

The waste material is directly loaded into vacuum in a holding tank, pre-heated and fed to a furnace where the volatile matter is gasified and fed directly into the plasma arc generator where it is pre-heated electrically and then passed through the plasma arc dissociating it into elemental stages. The gas output after scrubbing comprise mainly of CO and H_2. The liquefied produce is mainly methanol.

The entire process is claimed to safely treat any type of hazardous or non-hazardous materials. It has the advantage that the oxides of Nitrogen (Nox) and oxides of Sulphur (Sox) gaseous emissions do not occur in normal operation due to the lack of oxygen in the system.

Some United States companies offering PPV technology are Quantum Tech LLC and Global Plasma Systems, who are reported to be setting up some demonstration units based on this technology in Malaysia and Singapore.

16.7 REFUSE DERIVED FUEL

The process of conversion of garbage into fuel pellets involves primarily drying, separation of combustibles from garbage, size reduction and pelletisation after mixing with binder and/or additives as required.

The MSW collected for disposal is tested for its moisture content and when the moisture content is more than 35- 40%, it requires drying to produce fuel pellets with reasonable heating values. The reduction in moisture can be done artificially or by natural sun drying. Sun drying is preferred when adequate land is readily available. However, during periods of heavy rainfall, alternate arrangements for drying will have to be made. The moisture level of waste is brought down to around 35-40% by uniformly spreading it on an open, paved area and allowing it to sun dry. The duration of sun drying varies from 1 to 2 days depending upon the garbage quality. In the process of spreading the garbage, manual inspection is carried out to remove large debris, tree cuttings, tyres etc., which are harmful to the downstream process equipment.

The sun dried garbage is then uniformly fed into a rotary drying system i.e. Hot Air Generation burning oversize garbage or other fuel to further bring down the moisture level to about 10-12%. It is reported as well as proved that 10-12% moisture content is desirable to be maintained in the garbage for densifying into fuel pellets.

After drying is over, the garbage is passed through a screening equipment to separate sand/grit (below 8mm), heavier combustibles & ferrous materials which are abrasive in nature and may cause harm to process equipment. This fine fraction having organic matter in it is already proved to be useful as garden manure.

The dried and screened garbage is then passed through an Air-Classifier (Density Separator) in which the light combustibles and dense fractions (e.g. stones, glass etc.) are separated over an air barrier. At the same time, the garbage is passed over a magnetic separation unit to remove magnetic materials. The light combustibles are ground to 10/15mm particle size. The binder and/or additives are mixed with ground garbage in mixer/conditioner before pelletising. The pellets coming out of pelletiser are cooled and stored in the pellet storage yard for despatch. The pellets so produced can be used in industrial boilers and thermal power plants as fuel. A typical process flow diagram of a RDF plant is shown in Fig.16.1.

Studies were carried out in India on a plant to process 150 tonnes per day (t.p.d.) Municipal Solid Waste (MSW) to 80 t.p.d. pellets. The plant was funded by Department of Science & Technology (DST) and was set up in Mumbai in 1991. It was operated for sometime as a pilot plant but was closed down for various reasons. Based on this technology, a 350 t.p.d. plant to produce 100 t.p.d. pellets has been installed at Hyderabad through private sector participation.

16.8 HYDROPULPING

Due to high paper content in the waste from developed countries, a method has been developed to hydropulp the waste and recover paper fibre from refuse. The method is being used in a full scale plant of 150 tpd capacity operating at Franklin, Ohio, USA (Fig.16.2). The method is suitable for processing of paper waste. However, no such plant has yet been installed in India.

16.9 SLURRY CARB PROCESS

This process has been developed in USA by M/s Enertech Environmental Inc., USA to convert municipal solid waste into "Energy Fuel" (E-fuel) which is suitable for combustion in industrial and utility coal boilers. It is used in conjunction with a wet resources recovery process to separate out the recyclables. The waste slurry is then subjected to high pressure and temperature and undergoes thermal decomposition/carbonisation to "E-fuel". The received waste is first shredded and then placed in an industrial pulper. The heavier, more dense inorganic material sinks to the bottom of the water-filled pulper where it is easily removed. The organic fraction which remains, is subjected to violent pulping action which further reduces its particle size. The pulped organic waste is then subjected to a combination of temperature and pressure causing the waste to "carbonise" (a process which is similar to the natural formation of coal).

The process is claimed to lead to virtually 100% chlorine extraction, no dust or no net green house gases, no dioxin, furan and any heavy metals like mercury. The ash by product is claimed to be non-hazardous and can be used as base material for roads. The capital and recurring costs are claimed to be 20-50% less and the revenue as much as 40% more than in case of comparable incinerators.

16.10 TREATMENT FOR RECOVERY OF USEFUL PRODUCTS

Solid waste is a heterogenous mixture which contains various ingredients, some of which have a large resale/reuse potential. Solid waste in developed countries contains glass and ferrous as well as non-ferrous metals in large proportion. The energy required and the pollution caused to obtain a product from virgin material is more than that required for obtaining it from secondary sources as from MSW. Hence research efforts have been concentrated in this area. In India much of the useful constituents seldom reach the waste stream, though in industrial and commercial areas and in high income group areas such conditions may be encountered. Before any reusable components can be removed from MSW, size reduction is necessary to make it suitable for handling. It can then be

subjected to either incineration or pyrolysis followed by separation of usable constituents from the processed waste or to a detailed physical separation process.

Residue after incineration is smaller in volume, relatively pollution free and innocuous. However, it alters the form of many constituents which cannot be easily reused. Glass tends to melt to an intractable lump. Most of the plastics burn away and some of them like Poly Vinyl Chloride (PVC) while burning release halides resulting in chemical reactions that impair metal recovery. Metals may melt, get oxidised or converted to halide compounds and get lost in the gaseous effluents. Thus the recovered metals from incinerator residue will not be of very good quality. During pyrolysis, on the other hand, oxidation of metal components does not occur. The final product is in the form of a friable char which unlike incinerator residue does not require crushing to release values.

Shredded raw MSW can also be regarded as a multivalue ore and treated by mineral engineering methods into products which can serve as a potentially useful material. A number of organisations have come forward with flow sheets for recovery of various ingredients like glass, metals, etc. such as the one by U.S. Bureau of Mines (Fig. 16.3). In this process, the material is initially subjected to coarse shredding in a machine which breaks plastic and paper bags and boxes without damaging metal object. Glass is broken into pieces but not in fines. The material then passes under a magnetic separator where it is subjected to a vertical air classifier when the heavy objects fall through the vertical air stream while the lighter objects (paper, plastics, etc.) are carried away to a cyclone separator. The heavier particles are passed through a trommel screen of 57 mm (2.25") size. The fines are subjected to elutriation by water which helps separate glass from organic waste containing soil and glass. Oversize is processed by an optical color sorter into white and colored glass and oversize from the trommel is subjected to further shredding to 25-75 mm (1-3") followed by secondary air classification and water elutriation. Light material (paper and plastics) from the secondary cyclone is separated by the use of high tension electro-dynamic technique when paper is drawn to the electrode while plastic sticks to the drum and gets separated. The heavies from the secondary water elutriator mainly comprise of organic wastes and metallic aluminium. A similar flow-sheet has been developed by Warren Springs Laboratory, United Kingdom.

16.11 SUMMARY

Various processes have been developed and used in the developed countries. These are suitable for specific types of waste and a comparison is provided in Table 16.2.

Table 16.2 – Summary of basic principles for adoption of emerging technologies

S. No	Method	Basic principle	Suitability for Waste	Stage of development
1.	Vermicomposting	Decomposition through microbes such as fungi, actinomycetes, protozoa in the gut of earthworms	Organic waste with low organic & moisture content	Developed and adopted extensively
2.	Biogas from MSW	Anaerobic decomposition of organic matter	Organic matter	Developed & widely used in developed countries
3.	Conversion of solid waste to protein	Bacterial conversion	Cellulosic waste	Lab-scale in India well as in developed countries *
4.	Alcohol fermentation	Anaerobic decomposition	Cellulosic waste	Lab-scale
5.	Pyrolysis (including plasma arc technology)	Destructive distillation	Cellulosic waste	Used in Developed Countries
6.	Refuse derived fuel	Separation	High Cellulosic waste	Used in Developed Countries
7.	Hydropulping	Hydropulping	Paper waste	Used in Developed Countries
8.	Slurry carb process	Slurry formation followed by carbonisation	Paper waste	Used in Developed Countries
9.	Recovery of useful products	Separation	Low ash waste	Used in Developed Countries

***** Commercial viability yet to be established.

CHAPTER 17
LANDFILLS

17.1 INTRODUCTION

17.1.1 Definition

The term 'landfill' is used herein to describe a unit operation for final disposal of 'Municipal Solid Waste' on land, designed and constructed with the objective of minimum impact to the environment by incorporating eight essential components described in Section 17.3. This term encompasses other terms such as 'secured landfill' and 'engineered landfills' which are also sometimes applied to municipal solid waste (MSW) disposal units.

The term 'landfill' can be treated as synonymous to 'sanitary landfill' of Municipal Solid Waste, only if the latter is designed on the principle of waste containment and is characterised by the presence of a liner and leachate collection system to prevent ground water contamination. The term 'sanitary' landfill has been extensively used in the past to describe MSW disposal units constructed on the basis of 'dump and cover' but with no protection against ground water pollution. Such landfills do not fall under the term 'municipal solid waste landfills' as used in this chapter.

17.1.2 Landfilling of Municipal Solid Waste

(a) Landfilling will be done for the following types of waste:

- (i) Comingled waste (mixed waste) not found suitable for waste processing;
- (ii) Pre-processing and post-processing rejects from waste processing sites;
- (iii) Non-hazardous waste not being processed or recycled.

(b) Landfilling will usually not be done for the following waste streams in the municipal solid waste:

- (i) Biowaste/garden waste;
- (ii) Dry recyclables.

(c) Landfilling of hazardous waste stream in the municipal waste will be done at a hazardous waste landfill site; such a site will be identified by the State Government and is likely to be operated by industries of a district/state. If such a landfill is not available, municipal authorities will dispose the hazardous waste in a special hazardous waste cell in the MSW landfill as shown in Fig. 17.1. Such a cell will be designed as per Ministry of Environment and Forests (MoEF) guidelines for hazardous waste disposal.

(d) Landfilling of construction and demolition waste will be done in a separate landfill where the waste can be stored and mined for future use in earthwork or road projects. If such a landfill site is not available, the waste will be stored in a special cell at a MSW landfill from where it can be mined for future use. Construction and demolition waste can be used as a daily cover at MSW landfills; however only minimum thickness of cover should be provided as indicated in section 17.8.4.5. All excess construction waste should be stored in the separate landfill cell.

(e) All existing and old landfills will be inspected and boreholes will be drilled for (i) recovery of leachate samples from the base of the landfill, (ii) recovery of subsoil samples beneath the base of the landfill for evaluation of permeability and soil properties and (iii) recovery of waste samples for waste characterisation. A minimum of 3 boreholes will be drilled with atleast one borehole for each acre of landfill area. The quality of leachate samples will be compared with (a) the ground water quality in existing borewells 2 km away from the landfill and (b) the Central Pollution Control Board (CPCB) norms for limits of contaminants in leachate. If the leachate quality and the permeability of the subsoil strata is observed to be satisfactory, the existing landfill can continue to operate with bi-annual monitoring of leachate quality in the drilled boreholes.

(f) If the leachate quality is observed to be of poor quality with respect to the local ground water quality or with respect to the CPCB norms, steps will be taken to close the existing landfill site and remedial measures adopted. All future landfilling will be undertaken in properly designed and constructed new landfills.

(g) New landfills will be established as per the norms given in this chapter for siting (section 17.4), site investigations (section 17.5), design (sections 17.6 and 17.7), construction and operation (section 17.8) and closure (section 17.9).

(h) The estimated annual cost for setting up and operating new landfills as per norms given in this chapter is estimated to lie between Rs. 200 to 300 per tonne of waste generated (at 1998 prices, excluding land acquisition cost). Provisions may be made by the municipal authorities for allocating adequate financial resources for establishing new landfills.

17.2 ENVIRONMENTAL IMPACT AND ITS MINIMISATION

The impact of dumping municipal solid waste on land without any containment is shown in Fig. 17.2. One notes from this figure that such dumps cause the following problems:

(a) Groundwater contamination through leachate

(b) Surface water contamination through runoff

(c) Air contamination due to gases, litter, dust, bad odour

(d) Other problems due to rodents, pests, fire, bird menace, slope failure, erosion etc.

Landfills minimise the harmful impact of solid waste on the environment by the following mechanisms (Fig. 17.3): (a) isolation of waste through containment; (b) elimination of polluting pathways; (c) controlled collection and treatment of products of physical, chemical and biological changes within a waste dump – both liquids and gases; and (d) environmental monitoring till the waste becomes stable.

Landfill design philosophy in the early 1990's tended towards total containment or isolation of waste. It is now recognised that this is unattainable and that it is more appropriate to design for controlled release rather than attempt indefinite isolation because all containment systems will eventually allow passage of water beyond the design period. The basic philosophy of all modern landfills revolves around the concept that waste which will not become stable or inert with time will be treated as 'stored' and not 'disposed'.

17.3 ESSENTIAL COMPONENTS

The seven essential components of a MSW landfill (Figs. 17.4) are:

(a) A liner system at the base and sides of the landfill which prevents migration of leachate or gas to the surrounding soil.

(b) A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill and then treats the leachate.

(c) A gas collection and control facility (optional for small landfills) which collects and extracts gas from within and from the top of the landfill and then treats it or uses it for energy recovery.

(d) A final cover system at the top of the landfill which enhances surface drainage, prevents infiltrating water and supports surface vegetation.

(e) A surface water drainage system which collects and removes all surface runoff from the landfill site.

(f) An environmental monitoring system which periodically collects and analyses air, surface water, soil-gas and ground water samples around the landfill site.

(g) A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed and the activities for long-term monitoring, operation and maintenance of the completed landfill.

17.4 SITE SELECTION

Selection of a landfill site usually comprises of the following steps, when a large number (eg. 4 to 8) landfill sites are available: (i) setting up of a locational criteria; (ii) identification of search area; (iii) drawing up a list of potential sites; (iv) data collection; (v) selection of few best-ranked sites; (vi) environmental impact assessment and (vii) final site selection and land acquisition.

However, in municipalities where availability of land is limited, the selection process may be confined to only one or two sites and may involve the following steps: (i) Setting up of locational criteria; (ii) Data collection; (iii) Environmental impact assessment and (vi) Final site selection.

17.4.1 Locational Criteria

A locational criteria may be specified by a regulatory agency (e.g. Pollution Control Board). In the absence of regulatory requirements, the following criteria are suggested. If it is absolutely essential to site a landfill within a restricted zone(s) then appropriate design measures are to be adopted and permission from the regulatory agency should be sought:

(a) **Lake or Pond**: No landfill should be constructed within 200 m of any lake or pond. Because of concerns regarding runoff of waste water contact, a surface water monitoring program should be established if a landfill is sited less than 200m from a lake or pond.

(b) **River**: No landfill should be constructed within 100 m of a navigable river or stream. The distance may be reduced in some instances for non-meandering rivers but a minimum of 30 m should be maintained in all cases.

(c) **Flood Plain**: No landfill should be constructed within a 100 year flood plain. A landfill may be built within the flood plains of secondary streams if an embankment is built along the stream side to avoid flooding of the area. However, landfills must not be built within the flood plains of major rivers unless properly designed protection embankments are constructed around the landfills.

(d) **Highway**: No landfill should be constructed within 200 m of the right of way of any state or national highway. This restriction is mainly for aesthetic reasons. A landfill may be built within the restricted distance, but no closer than 50 m, if trees and berms are used to screen the landfill site.

(e) **Habitation**: A landfill site should be at least 500 m from a notified habitated area. A zone of 500 m around a landfill boundary should be declared a No-Development Buffer Zone after the landfill location is finalised.

(f) **Public parks**: No landfill should be constructed within 300 m of a public park. A landfill may be constructed within the restricted distance if some kind of screening is used with a high fence around the landfill and a secured gate.

(g) **Critical Habitat Area**: No landfill should be constructed within critical habitat areas. A critical habitat area is defined as the area in which one or more endangered species live. It is sometimes difficult to define a critical habitat area. If there is any doubt then the regulatory agency should be contacted.

(h) **Wetlands**: No landfill should be constructed within wetlands. It is often difficult to define a wetland area. Maps may be available for some wetlands, but in many cases such maps are absent or are incorrect. If there is any doubt, then the regulatory agency should be contacted.

(i) **Ground Water Table** : A landfill should not be constructed in areas where water table is less than 2m below ground surface. Special design measures be adopted, if this cannot be adhered to.

(j) **Airports**: No landfill should be constructed within the limits prescribed by regulatory agencies (MOEF/ CPCB/ Aviation Authorities) from time to time.

(k) **Water Supply Well:** No landfill should be constructed within 500 m of any water supply well. It is strongly suggested that this locational restriction be abided by at least for down gradient wells. Permission from the regulatory agency may be needed if a landfill is to be sited within the restricted area.

(l) **Coastal Regulation Zone**: A landfill should not be sited in a coastal regulation zone.

(m) **Unstable Zone** : A landfill should not be located in potentially unstable zones such as landslide prone areas, fault zone etc.

(n) **Buffer Zone** : A landfill should have a buffer zone around it, up to a distance prescribed by regulatory agencies.

(o) Other criteria may be decided by the planners.

17.4.2 Search Area

To identify the potential sites for a landfill a 'search area' has to be delineated. The search area is usually governed by the economics of waste transportation. It is usually limited by the boundaries of the municipality. Typically search areas are delineated on a map using a 'search radius' of 5 to 10 km, keeping the waste generating unit as the centre. Alternatively, the search area may be identified by adopting a range of 5 km all around the built-up city boundary. One should start with a small search area and enlarge it, if needed.

17.4.3 Development of a List of Potential Sites

After demarcating the search area, as well as after studying the various restrictions listed in the locational critieria, areas having potential for site development should be identified. A road map may be used to show the potential sites that satisfy the locational criteria. Preliminary data collection should be undertaken with an aim of narrowing the list of sites to a few best-ranked sites.

In areas where land availability is scarce, degraded sites such as abandoned quarry sites or old waste dump sites can be considered. Special design measures are required for such sites.

To estimate the area required for a landfill, the landfill capacity may be computed as indicated in Section 17.6.2 and Annexure 17.1 and the area required for the operative life of the landfill should be evaluated.

17.4.4 Data Collection

Several maps and other information need to be studied to collect data within the search radius. Some are discussed below.

(a) Topographic Maps: The topography of the area indicates low and high areas, natural surface water drainage pattern, streams, and rivers. A topographic map will help find sites that are not on natural surface water drains or flood plains. Topographical maps may be procured from Survey of India.

(b) Soil Maps: These maps, primarily meant for agricultural use, will show the types of soil near the surface. They are of limited use as they do not show types of soil a few metre below the surface. They can be procured from Indian Agricultural Research Institute (IARI).

(c) Land Use Plans: These plans are useful in delineating areas with definite zoning restrictions. There may be restrictions on the use of agricultural land or on the use of forest land for landfill purposes. These maps are used to delineate possible sites that are sufficiently away from localities and to satisfy zoning criteria within the search area. Such maps are available with the Town Planning authority or the Municipality.

(d) Transportation Maps: These maps, which indicate roads and railways and locations of airports, are used to determine the transportation needs in developing a site.

(e) Water Use Plans: Such maps are usually not readily available. However, once potential areas are delineated, the water use in those areas must be investigated. A plan indicating the following items should be developed: private and public tubewells indicating the capacity of each well, major and minor drinking water supply line(s), water intake wells located on surface water bodies, and open wells.

(f) Flood Plain Maps: These maps are used to delineate areas that are within a 100 year flood plain. Landfill siting must be avoided within the flood plains of major rivers.

(g) Geologic Maps: These maps will indicate geologic features and bedrock levels. A general idea about soil type can be developed from a geologic map. Such maps can be procured from Geological Survey of India. They may be used to identify predominantly sandy or clayey areas.

(h) Aerial Photographs/Satellite Imagery: Aerial photographs or satellite imageries may not exist for the entire search area. However such information may prove to be extremely helpful. Surface features such as small lakes, intermittent stream beds, and current land use, which may not have been identified in earlier map searches, can be easily identified using aerial photographs.

(i) Ground Water Maps: Ground water contour maps are available in various regions, which indicate the depth to ground water below the land surface as well as regional ground water flow patterns. Such maps should be collected from Ground Water Boards or Minor Irrigation Tubewell Corporations.

(j) Rainfall Data: The monthly rainfall data for the region should be collected from the Indian Meteorological Department.

(k) Wind Map: The predominant wind direction and velocities should be collected from the Indian Meteorological Department.

(l) Seismic Data: The seismic activity of a region is an important input in the design of landfills Seismic coefficients are earmarked for various seismic zones and these can be obtained from the relevant BIS code or from the Indian Meteorological Department.

17.4.5 Site Walk-Over and Establishment of Ground Truths

A site reconnaissance will be conducted by a site walk-over as a part of the preliminary data collection. All features observed in various maps will be confirmed. Additional information pertaining to the following will be ascertained from nearby inhabitants: (a) flooding during monsoons; (b) soil Type; (c) depth to G.W. Table (as observed in open wells or tube wells); (d) quality of groundwater and (e) Depth to bedrock.

17.4.6 Preliminary Boreholes and Geophysical Investigation

At each site, as a part of preliminary data collection, one to two boreholes will be drilled and samples collected at every 1.5m interval to a depth of 20m below the ground surface. The following information will be obtained: (i) soil type and stratification; (ii) permeability of each strata; (iii) strength and compressibility parameters (optional); (iv) ground water level and quality and (v) depth to bedrock.

In addition to preliminary boreholes, geophysical investigations (electrical resistivity/ seismic refraction/others) may be undertaken to assess the quality of bedrock at different sites.

17.4.7 Assessment of Public Reaction

The public/nearby residents should be informed of the possibility of siting of a landfill in a nearby even as soon as a list of potential sites is developed. A preliminary assessment of public opinion regarding all the sites in the list is essential.

A site may be technically and economically feasible yet may be opposed heavily by the public. The "not in my back yard" (NIMBY) sentiment is high initially. However, with proper discussion it can be overcome in some cases. Early assessment regarding how strong the NIMBY sentiment is, can significantly reduce the time and money spent on planning for a landfill site which may not materialise. In many instances residents around a proposed site cooperate if the landfill site owner's representative listens to concerns of the area residents and considers those concerns in designing and monitoring a site. Noise, dust, odour, increases in traffic volume, and reduction in property value concern the area residents more than the fear of groundwater contamination.

Public reaction is less hostile if landfilling is done in an area already degraded by earlier municipal waste dumps or other activities such as quarrying, ash disposal etc.

17.4.8 Selection of Few Best-Ranked Sites

From amongst a large number of sites, the selection of a final site will emerge from a two-stage approach.

(a) Selection of a few best-ranked sites (usually 2 sites, sometimes 3) on the basis of pathway and receptor related attributes.

(b) Selection of final site on the basins of environmental impact assessment, social acceptance and cost of disposal.

For the selection of a few best ranked sites, the Ranking System based on Site Sensitivity Index developed by Ministry of Environment and Forests (MOEF) in 1991is recommended. Only the following attributes should be considered in such a study as indicated: (a) population within 1 km; (b) distance to drinking water well/tubewell; (c) use of sites by residents; (d) distance to nearest offsite building; (e) presence of airport; (f) presence of roads; (g) current land use; (h) distance to critical habitat nearby; (i) distance to nearest surface water; (j) depth to ground water; (k) soil permeability; (l) depth to bedrock; (m) susceptibility to flooding; (n) susceptibility to water erosion; (o) slope Stability of final landform; (p) air pollution potential and (q) susceptibility to seismic activity.

On the basis of the ranking, scores received by various sites, one or two sites (sometimes up to 3) may be chosen for environmental impact assessment and final selection.

17.4.9 Environmental Impact Assessment (EIA)

Wherever feasible, environmental impact assessment will be conducted for two alternate sites (in exceptional circumstances up to 3 sites) The impact of the landfill on the following will be quantified: (a) Ground water quality; (b) Surface water quality; (c) Air quality – gases, dust, litter; (d) Aesthetics – visual, vermin, flies; (e) Noise; (f) Land use alteration; (g) Traffic alteration; (h) Drainage alteration; (i) Soil erosion; (j) Ecological impacts and (k) Others.

A comparison of both alternatives amongst themselves as well as with the null alternative (that is what would happen if the project was not carried out) should be made and suitability of the sites summarised.

EIA aspects are covered in Chapter 22.

17.4.10 Final Site Selection

The final selection of the site from amongst the best-ranked alternatives should be done by comparing:

(a) the environmental impact;

(b) social acceptance; and

(c) transportation and landfilling costs.

Transportation costs may be compared on the basis of average hauling distance from the centre of the waste generating unit (city or part thereof). Landfilling costs are difficult to compute at the preliminary stage but may be compared on the basis of the shape of the completed landfill and material costs for liner system, leachate collection system, daily covers and final cover system.

A landfill site with low environmental impact, high social acceptance and low costs is the most desirable. If conflicting results appear for (a), (b) and (c), environmental impact minimisation should normally be given top priority.

17.5 SITE INVESTIGATION AND SITE CHARACTERISATION

The data collected during site selection is not sufficient for landfill design. To be able to undertake detailed design of a landfill at a selected site, it is essential to characterise the landfill site and evaluate the parameters required for design. It is necessary that all data listed under section 17.4.4 on 'Data Collection' is collected for site characterisation. If some data has not been collected, the same should be obtained before site investigations are undertaken for site characterisation.

A proper site investigation programme comprises of subsoil investigation, ground water/hydrogeological investigation, hydrological investigation, topographical investigation, geological investigation, environmental investigation, traffic investigation and leachate investigation.

Table 17.1 indicates the types of investigations to be carried out for site characterisation including suggested minimum requirements of such investigations. The output expected from each investigation is listed below.

TABLE 17.1 : SUGGESTED INVESTIGATIONS FOR SITE CHARACTERISATION

Type of Investigation	Suggested Scope of Work
Subsoil/Geotechnical Investigation	(a) For Landifill design (i) Two boreholes per hectare of land; minimum 3 boreholes; upto 10m below base of landfill; recording soil strata, ground water level, bedrock level (ii) One to two in situ permeability tests per hectare of land (iii) Performance of SPT tests and collection of undisturbed samples from boreholes (iv) Laboratory tests on undisturbed samples - permeability, strength, compressibility, and classification tests. (b) For borrow area of liner material and cover material (i) Two test pits or shallow boreholes per hectare of borrow area; minimum five pits (ii) Laboratory tests - classification, Proctor compaction, permeability and strength tests (c) For approach road to landfill. (i) As per IRC codes

Type of Investigation	Suggested Scope of Work
Ground water/ Hydrogeological Investigations	(a) One ground water well (per acquifer) for every hectare of land; minimum four wells - one upgradient, three down-gradient (b) Observations of g.w. level fluctuations and ground water flow (c) Collection of groundwater samples (monthly/bi-monthly) for g.w. quality testing for 1 year prior to landfill construction.
Topographical Investigation	Surveying of landfill area and preparation of a topographical map with 0.3m contour interval.
Hydrological Investigation	(a) Collection of detailed topographical maps of surrounding area from Survey of India. (b) Collection of hydrometeorological data from India Meteorogical Department (c) Performance of flood routing analysis for one in 100 year flood (d) Collection of surface water samples (monthly/bimonthly) for water quality testing one year prior to landfill construction
Geological & Seismic Investigations	(a) Geophysical survey - seismic refraction or microgravity for bedrock profiling (b) Joint mapping of exposed rock outcrop/quarry face. (c) Collection of seismic data
Environmental Investigation basis	(a) Collection of samples on monthly/bimonthly surface water samples ground water samples, and air samples (b) Transportation to certified testing laboratory and testing for regulatory parameters (c) Vegetation/ecology mapping survey
Traffic Investigation	(a) Collection of data on existing traffic - daily traffic volume and peak hour traffic volume - for six months (b) Road condition survey for existing road with suggestions for strengthening/widening.

Type of Investigation	Suggested Scope of Work
Waste & Leachate Investigation	(a) Waste characterisation of fresh waste collected from bins (b) Waste characterization of old waste collected from different depths in existing waste dumps or sanitary landfills. (c) Collection and laboratory testing of at least 6 samples of leachate from just beneath existing waste dumps or sanitary landfills. (d) Estimate of leachate quality from laboratory testing.

17.5.1 Subsoil Investigation

The suggested minimum recommended investigations is listed in Table 17.1. A detailed investigation plan may be drawn up in consultation with a geotechnical engineer.

The output from such an investigation should yield the following:

(a) Stratification of subsoil – type of soil and depth

(b) Depth to ground water table and bedrock (if located within 10m of base of landfill)

(c) Permeability of various strata beneath the landfill

(d) Strength and compressibility properties of subsoil

(e) Extent of availability of liner material, drainage material, top soil, and protective soil in adjacent borrow areas

(f) Subsoil properties along approach road.

17.5.2 Ground Water/Hydrogeological Investigation

The suggested minimum investigation is listed in Table 17.1. A detailed investigation plan may be drawn up in consultation with a ground water specialist/water resources engineer or a hydrogeologist. The output from such an investigation should yield the following:

(a) Depth to groundwater table and its seasonal variations

(b) Ground water flow direction

(c) Baseline ground water quality parameters – all drinking water quality parameters

17.5.3 Topographical Investigation

Construction of a landfill involves a large quantity of earthwork. It is essential to have an accurate topographical map of the landfill site to compute earthwork quantities precisely. A map of 0.3m contour interval is considered desirable.

17.5.4 Hydrological Investigation

The objective of a hydrological investigation is to estimate the quantity of surface runoff that may be generated within the landfill to enable appropriate design of drainage facilities. If additional run off from areas external to the landfill is likely to enter the landfill, this quantity should also be estimated to design interception ditches and diversion channels. Such an investigation should yield estimates of peak flows. If seasonal rivers or streams run close to the site, hydrological investigation should indicate the possibility of flooding of the site under one in 100 year flood flows.

Surface water samples for water quality analysis may be collected from during hydrological studies.

17.5.5 Geological Investigation and Seismic Investigation

Geological investigations should delineate the bedrock profile beneath the landfill base, if not confirmed by subsoil investigations. Geophysical surveys may be designed in consultation with a geologist.

In hilly areas or in quarried rocks, geological investigations should indicate the quality of surficial rock, depth to sound rock and the possibility of interconnected aquifers beneath the landfill base in the rock mass.

Detailed seismic data may be obtained as a part of geological investigations (if required).

17.5.6 Environmental Investigation

The following baseline parameters must be established for a one year period prior to construction of a landfill:

(a) **Ground Water Quality**: Minimum of 3 samples from each aquifer analysed in monthly basis for drinking water quality parameters.

(b) **Surface Water Quality**: Minimum of 3 samples from a stream/storm water drain analysed on a monthly basis and for parameters relevant for waste-water drains.

(c) **Landfill Gas**: Sampling and analysis for methane, hydrogen sulphide and other gases on a monthly basis.

(d) **Dust**: PM 10 (Particle size less than 10 Microns) monitoring on a monthly basis, specifically at noon, during hot, dry, windy days.

(e) **Odour**: Monthly analysis at the site and at 200m intervals from the landfill boundary to the nearest inhabited zone.

(f) **Noise**: Peak noise analysis at the site and nearby inhabited zone on a monthly basis.

(g) **Vegetative Cover**: Vegetative mapping on a seasonal basis.

17.5.7 Traffic Investigation

Traffic investigations must be conducted to identify peak traffic volume as well as the quality of existing roads near the landfill. The influence of increased heavy vehicle traffic due to landfilling should be analysed with a view to widening the existing road.

17.5.8 Waste Characterisation

Waste characterisation is normally conducted as a part of waste management studies or environmental impact assessment studies. Waste from all sources must be tested for the following properties: (a) composition; (b) physical properties; (c) chemical properties; (d) biological properties; (e) thermal properties; (f) toxic properties and (g) geotechincal properties.

17.5.9 Leachate Investigation

Leachate quality can be assessed from both laboratory studies and field studies. Laboratory leachate tests may be performed. In addition, (if feasible), leachate samples should be analysed from existing waste dumps or landfills near the new site. This will help in a leachate treatment strategy.

17.6 LANDFILL PLANNING AND DESIGN

17.6.1 Design Life

A landfill design life will comprise of an 'active' period and an 'closure and post-closure' period. The 'active' period may typically range from 10 to25 years depending on the availability of land area. The 'closure and post-closure' period for which a landfill will be monitored and maintained will be 25 years after the 'active period' is completed.

17.6.2 Waste Volume and Landfill Capacity

The volume of waste to be placed in a landfill will be computed for the 'active' period of the landfill taking into account (a) the current generation of water per annum and (b) the anticipated increase in rate of waste generation on the basis of past records or population growth rate.

The required landfill capacity is significantly greater than the waste volume it accommodates. The actual capacity of the landfill will depend upon the volume occupied by the liner system and the cover material (daily, intermediate and final cover) as well as the compacted density of the waste. In addition, the amount of settlement a waste will undergo due to overburden stress and due to bio-degradation should also be taken into account.

The density of waste varies on account of large variations in waste composition, degree of compaction and state of decomposition. Densities may range as low as 0.40 t/cu.m. to 1.25 t/cu.m. For planning purposes, a density of 0.85 t/cu.m. may be adopted for biodegradable wastes with higher values (typically 1.1 t/cu.m.) for inert waste.

Settlement of the completed waste mass beneath the final cover will inevitably occur as a result of the consolidation of waste within a landfill site. Initial settlement occurs predominantly because of the physical rearrangements of the waste material after it is first placed in the landfill. Later settlement mainly results from biodegradation of the waste, which in turn leads to further physical settlement. Accurate prediction of settlement is difficult because time-related settlement data are not readily rarely available. Initial settlement values of between 12 and 17% have been reported for household waste sites in the UK with long term (30 year) values of approximately 20%. A typical allowance of 10% can be made when usable landfill capacity is computed (less than 5% for incinerated/inert waste).

Annexure 17.1 gives the methodology for computing the landfill capacity, landfill area and landfill height.

The total landfill area should be approximately 15% more than the area required for landfilling to accommodate all infrastructure and support facilities as well as to allow the formation of a green belt around the landfill.

There is no standard method for classifying landfills by their capacity. However the following nomenclature is often observed in literature:

Small size landfill	:	less than 5 hectare area
Medium size landfill	:	5 to 20 hectare area
Large size landfill	:	greater than 20 hectare area.

Landfill heights are reported to vary from less than 5 m to well above 30 m.

17.6.3 Landfill Layout

A landfill site will comprise of the area in which the waste will be filled as well as additional area for support facilities. Within the area to be filled, work may proceed in phases with only a part of the area under active operation. A typical site layout is shown in Fig. 17.5. The following facilities must be located in the layout: (a) access roads; (b) equipment shelters; (c) weighing scales; (d) office space; (e) location of waste inspection and transfer station (if used); (f) temporary waste storage and/or disposal sites for special wastes; (g) areas to be used for waste processing (e.g. shredding); (h) demarcation of the landfill areas and areas for stockpiling cover material and liner material; (i) drainage facilities; (j) location of landfill gas management facilities; (k) location of leachate treatment facilities; and (l) location of monitoring wells.

It is recommended that for each landfill site, a layout be designed incorporating all the above mentioned facilities (see Section 17.6.17 on Site Infrastructure for details). The layout will be governed by the shape of the landfill area in plan.

17.6.4 Landfill Section

Landfills may have different types of sections depending on the topography of the area. The landfills may take the following forms: (a) above ground landfills (area landfills); (b) below ground landfill (trench landfills); (c) slope landfills; (d) valley landfills (canyon landfills); and (e) a combination of the above. Fig. 17.6 shows typical landfill sections.

Above Ground Landfill (Area Landfill): The area landfill [Figs. 17.6(a)] is used when the terrain is unsuitable for the excavation of trenches in which to place the solid waste. High-groundwater conditions necessitate the use of area-type landfills. Site preparation includes the installation of a liner and leachate control system. Cover material must be hauled in by truck or earthmoving equipment from adjacent land or from borrow-pit areas.

Below Ground Landfill (Trench Landfill): The trench method of landfilling [Fig. 17.6(b)] is ideally suited to areas where an adequate depth of cover material is available at the site and where the water table is not near the surface. Typically, solid wastes are placed in trenches excavated in the soil. The soil excavated from the site is used for daily and final cover. The excavated trenches are lined with low-permeability liners to limit the movement of both landfill gases and leachate. Trenches vary from 100 to 300 m in length, 1 to 3 m in depth, and 5 to 15 m in width with side slopes of 2:1.

Slope Landfill: In hilly regions it is usually not possible to find flat ground for landfilling. Slope landfills and valley landfills have to be adopted. In a slope landfill [Fig. 17.6(c)], waste is placed along the sides of existing hill slope. Control of inflowing water from hillside slopes is a critical factor in design of such landfills.

Valley Landfill: Depressions, low-lying areas, valleys, canyons, ravines, dry borrow pits etc. have been used for landfills. The techniques to place and compact solid wastes in such landfills [Fig. 17.6(d)] vary with the geometry of the site, the characteristics of the available cover material, the hydrology and geology of the site, the type of leachate and gas control facilities to be used, and the access to the site. Control of surface drainage is often a critical factor in the development of canyon/depression sites.

It is recommended that the landfill section be arrived at keeping in view the topography, depth to water table and availability of daily cover material.

17.6.5 Phased Operation

Before the main design of a landfill can be undertaken it is important to develop the operating methodology. A landfill is operated in phases because it allows the progressive use of the landfill area, such that at any given time a part of the site may have a final cover, a part being actively filled, a part being prepared to receive waste, and a part undisturbed;

The term ‘phase’ describes a sub-area of the landfill. A ‘phase’ consists of cells, lifts, daily cover, intermediate cover, liner and leachate collection facility, gas control facility and final cover over the sub-area.

Each phase is typically designed for a period of 12 months. Phases are generally filled from the base to the final/intermediate cover and capped within this period leaving a temporary unrestored sloping face. Fig. 17.7 shows a simplified sequence of phased operation.

It is recommended that a ‘phase plan’ may be drawn as soon as the landfill layout and section are finalised. It must be ensured that each phase reaches the final cover level at the end of its construction period and that is capped before the onset of monsoons. For very deep or high landfills, successive phases should move from base to the top (rather than horizontally) to ensure early capping and less exposed plan area of ‘active’ landfills (Fig. 17.8).

The term cell is used to describe the volume of material placed in a landfill during one operating period, usually one day (see Fig. 17.9). A cell includes the solid waste deposited and the daily cover material surrounding it. Daily cover usually consists of 15 to 30 cm of native soil that is applied to the working faces of the landfill at the end of each operating period. The purposes of daily cover are to control the blowing of waste materials; to prevent rate, flies and other disease vectors from entering or exiting the landfill; and to control the entry of water into the landfill during operation.

A lift is a complete layer of cells over the active area of the landfill (Fig. 17.9). Typically, each landfill phase is comprised of a series of lifts. Intermediate covers are placed at the end of each phase; these are thicker than daily covers, typically 45 cm or more and remain exposed till the next phase is placed over it. A bench (or terrace) is commonly used where the height of the landfill will exceed 5 m. The final lift includes the cover layer. The final cover layer is applied to the entire landfill surface of the phase after all landfilling operations are complete. The final cover usually consists of multiple layers designed to enhance surface drainage, intercept percolating water and support surface vegetation.

17.6.6 Estimation of Leachate Quality and Quantity

Leachate is generated on account of the infiltration of water into landfills and its percolation through waste as well as by the squeezing of the waste due to self weight. Thus, leachate can be defined as a liquid that is produced when water or another liquid comes in contact with solid waste. Leachate is a contaminated liquid that contains a number of dissolved and suspended materials.

17.6.6.1 Leachate Quality

The important factors which influence leachate quality include waste composition, elapsed time, temperature, moisture and available oxygen. In general, leachate quality of the same waste type may be different in landfills located in different climatic regions. Landfill operational practices also influence leachate quality.

Table 17.2 indicates the typical data on characteristics of leachate reported by Bagchi (1994), Tchobanoglous et al. (1993) and Oweis and Khera (1990). Data on leachate quality has not been published in India. However, studies conducted by Indian Institute of Technology, Delhi, NEERI, Nagpur, and some State Pollution Control Boards have shown ground water contamination potential beneath sanitary landfills.

TABLE 17.2 : TYPICAL CONSTITUENTS OF LEACHATE FROM MSW LANDFILLS

Constituent		Range (mg/l)	
Type	**Parameter**	**Minimum**	**Maximum**
Physical	pH	3.7	8.9
	Turbidity	30JTU	500JTU
	Conductivity	480 mho/cm	72500 mho/cm
Inorganic	Total Suspended Solids	2	170900
	Total Dissolved Solids	725	55000
	Chloride	2	11375
	Sulphate	0	1850
	Hardness	300	225000
	Alkalinity	0	20350
	Total Kjeldahl Nitrogen	2	3320
	Sodium	2	6010
	Potassium	0	3200
	Calcium	3	3000
	Magnesium	4	1500
	Lead	0	17.2
	Copper	0	9.0
	Arsenic	0	70.2
	Mercury	0	3.0
	Cyanide	0	6.0
Organic	COD	50	99000
	TOC	0	45000
	Acetone	170	11000
	Benzene	2	410

	Toluene	2	1600
	Chloroform	2	1300
	Delta	0	5
	1,2 dichloroethane	0	11000
	Methyl ethyl ketone	110	28000
	Naphthalene	4	19
	Phenol	10	28800
	Vinyl Chloride	0	100
Biological	BOD	0	195000
	Total Coliform bacteria	0	100
	Fecal Coliform bacteria	0	10

(Source : Table compiled from data reported by Bagchi (1994), Tchobanoglous et. al. (1993) and Oweis and Khera (1990). Range of constituents observed from different landfills)

Assessment of leachate quality at an early stage may be undertaken to: (a) to identify whether the waste is hazardous, (b) to choose a landfill design, (c) to design or gain access to a leachate treatment plant, and (d) to develop a list of chemicals for the groundwater monitoring program. To assess the leachate quality of a waste, the normal practice is to perform laboratory leachate tests [Toxicity Characteristics Leaching Procedure (TCLP tests)] as well as to determine the quality of actual landfill leachate, if available. Difficulty arises when field data are not available for a particular waste type. Laboratory leachate tests on MSW do not yield very accurate results because of heterogeneity of the waste as well as difficulty in simulating of time-dependent field conditions. Leachate samples from old landfill sites near the design site may give some indication regarding leachate quality; however this too will depend on the age of the landfill.

For the design of MSW landfills having significant biodegradable material as well as mixed waste, leachate quality has been universally observed to be harmful to ground water quality. Hence all landfills will be designed with a liner system at the base as discussed in the Section 17.7 on Liner System.

A landfill may not be provided a liner if and only if the following conditions can be satisfied:

(a) if the waste is predominantly construction material type inert waste without any undesirable mixed components (such as paints, varnish, polish etc.) and if laboratory tests (such as TCLP tests) conclusively prove that the leachate from such waste is within permissible limits; and

(b) if the waste has some biodegradable material, it must be proven through both laboratory studies on fresh waste and field studies (in old dumps) that the leachate from such waste will not impact the ground water in all the phases of the landfill and has not impacted the ground water or the subsoil so far in old dumps. Such a case may occur at sites where the base soil may be clay of permeability less than 10^{-7} cm/sec for at least 5 m depth below the base and where water table is at least 20 m below the base. A leachate collection facility would have to be provided in all such cases.

17.6.6.2 Leachate Quantity

The quantity of leachate generated in a landfill is strongly dependent on the quantity of infiltrating water. This, in turn, is dependent on weather and operational practices. The amount of rain falling on a landfill to a large extent controls the leachate quality generated. Precipitation depends on geographical location.

Significant quantity of leachate is produced from the 'active' phases of a landfill under operation during the monsoon season. The leachate quantity from those portions of a landfill which have received a final cover is minimal. Fig. 17.10 shows the components of a water-balance approach for estimating leachate quantity for (a) actual condition and (b) simplified condition.

Generation Rate in 'Active Area': The leachate generation during the operational phase from an active area of a landfill may be estimated in a simplified manner as follows:

Leachate volume = (volume of precipitation) + (volume of pore squeeze liquid) – (volume lost through evaporation) – (volume of water absorbed by the waste).

Generation Rate After Closure: After the construction of the final cover, only that water which can infiltrate through the final cover percolates through the waste and generates leachate. The major quantity of precipitation will be converted to surface runoff and the quantity of leachate generation can be estimated as follows:

Leachate volume = (volume of precipitation) – (volume of surface runoff) – (volume lost through evapotranspiration) – (volume of water absorbed by waste and intermediate soil covers).

For landfills which do not receive run-on from outside areas, a very approximate estimate of leachate generation can be obtained by assuming it to be 25 to 50 per cent of the precipitation from the active landfill area and as 10 to 15 percent of the precipitation from covered areas. This is a thumb rule and can only be used for preliminary design.

For detailed design, computer simulated models [eg. Hydraulic Evaluation of Landfill Performance (HELP)] have to be used for estimation of leachate quantity generation. It is recommended that for design of all major landfills, such studies be conducted to estimate the quantity of leachate.

17.6.7 Liner System

Leachate control within a landfill involves the following steps: (a) prevention of migration of leachate from landfill sides and landfill base to the subsoil by a suitable liner system; and (b) drainage of leachate collected at the base of a landfill to the sides of the landfill and removal of the leachate from within the landfill.

Liner systems comprise of a combination of leachate drainage and collection layer(s) and barrier layer(s) (Fig. 17.11). A competent liner system should have low permeability, should be robust and durable and should be resistant to chemical attack, puncture and rupture. A liner system may comprise of a combination of barrier materials such as natural clays, amended soils and flexible geomembranes. Three types of liner systems (Fig. 17.12) are usually adopted and these are described hereafter:

(a) **Single Liner System**: Such a system comprises of a single primary barrier overlain by a leachate collection system with an appropriate separation/protection layer. A system of this type is used for a low vulnerability landfill.

(b) **Single Composite Liner System**: A composite liner comprises of two barriers, made of different materials, placed in intimate contact with each other to provide a beneficial combined effect of both the barriers. Usually a flexible geomembrane is placed over a clay or amended soil barrier. A leachate collection system is placed over the composite barrier. Single composite liner system are often the minimum specified liner system for non-hazardous wastes such as MSW.

(c) **Double Liner System**: In a double liner system a single liner system is placed twice, one beneath the other. The top barrier (called the primary barrier) is overlaid by a leachate collection system. Beneath the primary barrier, another leachate collection system (often called the leak detection layer) is placed followed by a second barrier (the secondary barrier). This type of system offers double safety and is often used beneath industrial waste landfills. It allows the monitoring of any seepage which may escape the primary barrier layer.

The advantages of a composite liner system are immense and often not widely recognised. The way that a composite liner works is sketched in Fig. 17.13 and is contrasted with individual geomembranes and soil liners. To achieve good composite action, the geomembrane must be placed against the clay with good hydraulic contact. To achieve intimate contact, the surface of a compacted soil liner on which the geomembrane is placed should be smooth-rolled with a steel-drum roller. All oversize stones in the soils should be removed prior to rolling. Also, the geomembrane should be placed and backfilled in a way that minimizes wrinkles.

On a basis of review of liner systems adopted in different countries (Fig. 17.14), it is recommended that for all MSW landfills the following single composite liner system be adopted (waste downwards) as the minimum requirement (Fig. 17.15):

(a) A leachate drainage layer 30 cm thick made of granular soil having permeability (K) greater than 10^{-2} cm/sec.

(b) A protection layer (of silty soil) 20 cm to 30 cm thick.

(c) A geomembrane of thickness 1.5 mm or more.

(d) A compacted clay barrier or amended soil barrier of 1 m thickness having permeability (K) of less than 10^{-7} cm/sec.

The liner system adopted at any landfill must satisfy the minimum requirements published by regulatory agencies (MOEF/ CPCB).

The liner system may have to be more stringent in free draining alluvial soils at locations where water table level is close to the base of the landfill.

The recommendations for the liner system are not expected to be reduced. However in circumstances where it can be proven by subsoil investigations as well as by hydrological investigations that the leachate will not cause harmful impact to the soil as well as ground water, the norms can be reduced after approval by the regulatory authority.

Detailed design and construction aspects of liners are covered in Section 17.7.

New materials can be considered for liner systems if:

(a) these are approved by regulatory agencies; and

(b) the use of such materials has been demonstrated over a 10 year period.

Cut-Off Walls: When a landfill is underlain, at shallow depths, by an impervious layer, vertical cutoff walls may be constructed around a landfill to intercept off-site migration. Cut-off walls are physical barriers (typical made of bentonite or bentonite-soil mix) and such barriers are aided by active pumping used to remove leachates from within the perimeter of the cutoff wall.

Liners for Steep Slopes and Vertical Quarry Faces: Liners along very steep slopes and vertical faces require site specific solutions which are usually complex.

17.6.8 Leachate Drainage, Collection and Removal

A leachate collection system comprises of a drainage layer, a perforated pipe collector system, sump collection area, and a removal system.

The leachate drainage layer is usually 30 cm thick, has a slope of 2% or higher and a permeability of greater than 0.01 cm/sec. A system of perforated pipes and sumps are provided within the drainage layer (Figs. 17.16). The pipe spacing is governed by the requirement that the leachate head should not be greater than the drainage layer thickness. Fig. 17.17 shows a typical layout of pipes and sumps. Pipe material selection is based on design requirements. HDPE pipes are most commonly used; other materials can also be examined for feasibility.

Leachate is removed from the landfill (Fig. 17.18) by (a) pumping in vertical wells or chimneys, (b) pumping in side slope risers, or (c) by gravity drains rough the base of a landfill in above-ground and sloped landfills. Side slope risers are preferred to vertical wells to avoid any down drag problems. Submersible pumps have been used for pumping for several years; educator pumps are also being increasingly used. In some landfills, the leachate is stored in a holding tank (for a few days) before being sent for treatment.

The possibility of fall in efficiency of the drainage system due to clogging associated with solid deposits and microbial growth is now well recognised. A number of options, including backflushing or breakthrough water after leachate head build-up need to be investigated at the design stage.

The design steps for the leachate collection system are:

(a) finalisation of layout pipe network and sumps in conjunction with drainage layer slopes of 2%;

(b) estimation of pipe diameter and spacing on the basis of estimated leachate quantity and maximum permissible leachate head;

(c) estimating the size of sumps and pump;

(d) design of wells/side slopes risers for leachate removal; and

(e) design of a holding tank.

It is recommended that the detailed methodology given in Sharma and Lewis (1994) be adopted.

17.6.9 Leachate Management

The alternatives to be considered for leachate management are:

(a) **Discharge to Lined Drains**: This option is usually not feasible. It can only be adopted if the leachate quality is shown to satisfy all waste water discharge standards for lined drains, consistently for a period of several years.

(b) **Discharge To Waste Water Treatment System**: For landfills close to a waste water treatment plant, leachate may be sent to such a plant after some pretreatment. Reduction is organic content is usually required as a pretreatment.

(c) **Recirculation**: One of the methods for treatment of leachate is to recirculate it through the landfill. This has two beneficial effects: (i) the process of landfill stabilisation is accelerated and (ii) the constituents of the leachate are attenuated by the biological, chemical and physical changes occurring with the landfill. Recirculation of a leachate requires the design of a distribution system to ensure that the leachate passes uniformly throughout the entire waste. Since gas generation is faster in such a process, the landfill should be equipped with a well designed gas recovery system.

(d) **Evaporation of Leachate**: one of the techniques used to manage leachate is to spray it in lined leachate ponds and allow the leachate to evaporate. Such ponds have to be covered with geomembranes during the high rainfall periods. The leachate is exposed during the summer months to allow evaporation. Odour control has to be exercised at such ponds.

(e) **Treatment of Leachate**: The type of treatment facilities to be used depend upon the leachate characteristics. Typically, treatment may be required to reduce the concentration of the following prior to discharge: degradable and non-degradable organic materials, specific hazardous constituents, ammonia and nitrate ions, sulphides, odorous compounds, and suspended solids. Treatment processes may be biological processes (such as activated sludge, aeration, nitrification (dentrification), chemical processes (such as oxidation, neutralisation) and physical processes (such as air stripping, activated adsorption, ultra filtration etc.). The treated leachate may be discharged to surface water bodies.

A leachate recirculation facility should be designed by a water supply specialist in conjunction with a geotechnical engineer. Procedures for design of recirculation facility are yet to be standardised and one may refer to Koerner and Daniel (1997) for further details. A leachate treatment facility should be designed by a waste water treatment specialist. The treatment facility will depend on the quality of the leachate and some treatment systems are discussed by Hogland (1997).

17.6.10 Estimation of Landfill Gas Quality and Quantity

Landfill gas is generated as a product of waste biodegradation. Biological degradation of the waste may occur in the presence of oxygen (aerobic bacteria), in an environment devoid of oxygen (anaerobic bacteria), or with very little oxygen (facultative anaerobic bacteria).

In all cases, organic waste is broken down by enzymes produced by bacteria in a manner comparable to food digestion. Considerable heat is generated by these reactions with methane, carbon dioxide, and other gases as the by-products. The typical percentage distribution of gases found in a MSW landfill is reported in Table 17.3 by Bagchi (1994). Tchobanoglous et. al. (1993) and Owies and Khera (1990). Methane and carbon dioxide are the principal gases produced from the anaerobic decomposition of the biodegradable organic waste components in MSW. When methane is present in the air in concentrations between 5 and 15 percent, it is explosive. Because only limited amounts of oxygen are present in a landfill when methane concentrations reach this critical level, there is little danger that the landfill will explode. However, methane mixtures in the explosive range can form if landfill gas migrates off-site and mixes with air. Published data on landfill gas quality in India is not available in literature.

The rate and quantity of gas generation with time, is difficult to predict. Typical generation rates reported in literature vary from 1.0 to 8.0 litres/kg/year. Bhide (1993) has reported landfill gas production rates of 6-0 cu.m. per hour from landfill sites in India having an area of 8 hectares and a depth of 5 to 8 m.

The experience of Sweden [Hogland (1997)] in the area of landfill gas generation is summarised hereafter and may be noted.

The potential volume of landfill gas generation can be estimated to be 200 to 300 cu.m. per tonne of municipal waste. 50 to 75 percent of this gas can be recovered in mixed waste landfills using well functioning recovery systems. The recovery time is difficult to predict and may vary from 10 to 20 years or even more.

TABLE 17.3 : TYPICAL CONSTITUENTS OF MUNICIPAL LANDFILL GAS

Constituent	Range (Percentage or Concentration)
Major Constituents	
Methane	30 to 60 %
Carbon Dioxide	34 to 60 %
Nitrogen	1 to 21 %
Oxygen	0.1 to 2 %
Hydrogen Sulphide	0 to 1 %
Carbon Monoxide	0 to 0.2 %
Hydrogen	0 to 0.2 %
Ammonia	0.1 to 1 %
Trace Constituents	
Acetone	0 to 240 ppm
Benzene	0 to 39 ppm
Vinyl Chloride	0 to 44 ppm
Toluene	8 to 280 ppm
Chloroform	0 to 12 ppm
Dichloromethane	1 to 620 ppm
Diethylene Chloride	0 to 20 ppm
Vinyl Acetate	0 to 240 ppm
Trichloroethane	0 to 13 ppm
Perchloroethane	0 to 19 ppm
Others	Variable

Gas outputs of 10 to 20 cu.m. per hour (corresponding to 50 to 100 KW of energy) have been recorded in wells of 15 to 20 cm diameter drilled 10 m into waste at a spacing of 30 to 70 m. For 1 MW output from a landfill site, 15 to 20 such wells are required.

Recovery of landfill gas from shallow depth landfills is more difficult than from landfill of depths greater than 5 m.

Landfill gases can move upward or downward in a landfill depending on their density. Although most of the methane escapes to the atmosphere, both methane and carbon dioxide have been found at concentrations up to 40 per cent at lateral distances of 100m or more from the edges of unlined landfills. For unvented landfills, the extent of this lateral movement varies with the characteristics of the cover material and the surrounding soil. If methane is vented in an uncontrolled manner, it can accumulate (because its density is less than that of air) below buildings or in other enclosed spaces close to a sanitary landfill. With proper venting, methane should not pose a problem (except that it is a greenhouse gas). Carbon dioxide, on the other hand, is troublesome because of its high density. The concentration of carbon dioxide in the lower portions of a landfill may be high for years.

Gas control within a landfill site (Fig. 17.19) involves the following features: (a) a containment system which encloses the gas within the site and prevents migration outside the landfill, (b) a system (passive or active) for collecting and removing landfill gas from within the landfill and in particular from the perimeter of the landfill; (c) a system for flaring or utilising the collected gas with adequate back-up facilities.

Landfill gas containment, extraction and use is discussed in Chapter 15.

17.6.12 Landfill Gas Management

The gas management strategies should follow one of the following three plans:

(a) Controlled passive venting

(b) Uncontrolled release

(c) Controlled collection and treatment/reuse

For all MSW landfills, controlled passive venting is recommended. Only for small (less than 100 tons per day), shallow (less than 5 m deep) and remotely located landfills, should uncontrolled release be allowed. Landfill gas monitoring will be adopted at all sites and remedial measure (such as flaring) undertaken if the gas concentrations are above acceptable limits.

Controlled collection and treatment/use will be adopted only after the feasibility of such a system is established and proven by an agency having experience in this area.

17.6.13 Final Cover System

A landfill cover is usually composed of several layers, each with a specific function. The final cover system must enhance surface drainage, minimise

infiltration, vegetation and control the release the landfill gases. The landfill cover system to be adopted will depend on the gas management plan i.e. (a) controlled passive venting; (b) uncontrolled release; or (c) controlled collection and treatment/reuse.

For all landfill sites where controlled gas venting is planned, the cover system shown in Fig. 17.20 is recommended. Gas vents will be placed at a spacing of 30 m to 75 m on the landfill cover and the level of methane will be monitored regularly. If methane concentration exceeds permissible limit a gas collection and treatment system will be installed with flaring facility.

For sites where landfill gas recovery is to be undertaken, the placement of passive and/or active gas venting systems will be governed by the energy recovery system. The cover system for such a site is shown in Fig. 17.21. Such a cover system minimises loss of gas to the environment.

For uncontrolled release of gas (in small, shallow and remote sites) the cover system shown in Fig. 17.22 is recommended.

The cover system adopted at any landfill must satisfy the minimum requirements published by regulatory agencies (MOEF/ CPCB).

17.6.14 Surface Water Drainage System

Surface water management is required to ensure that rainwater run-off does not drain into the waste from surrounding areas and that there is no water-logging/ponding on covers of landfills.

These objectives should be achieved by the following:

(a) Rainwater running off slopes above and outside the landfill area should be intercepted and channelled to water courses without entering the operational area of the site. This diversion channel may require a low permeability lining to prevent leakage into the landfill.

(b) Rain falling on active tipping areas should be collected separately and managed as leachate, via the leachate collection drain and leachate collection sumps to the leachate treatment and disposal system.

(c) Rainfall on areas within the landfill site but on final covers of phases which have been completed are not actively being used for waste disposal should be diverted away in drainage channels from active tipping areas, and directed through a settling pond to remove suspended silt, prior to discharge.

(d) Any drainage channels or drains constructed on the restored landfill surface should be able to accommodate settlement, resist erosion and cope with localised storm conditions.

(e) The final cover should be provided a slope of 3 to 5% for proper surface water drainage.

(f) All interceptor channels, drainage channels and settling ponds (storm water basins) should be designed by a hydrologist using hydrometerological data.

Fig. 17.23 shows a typical location of surface drainage facilities on completed landfill. Design of channels, ditches, culverts and basins is detailed by Bagchi (1994).

17.6.15 Slope Stability Aspects and Seismic Aspects

The stability of a landfill should be checked for the following cases (Fig. 17.24):

(a) stability of excavated slopes

(b) stability of liner system along excavated slopes

(c) stability of temporary waste slopes constructed to their full height (usually at the end of a phase)

(d) stability of slopes of above-ground portion of completed landfills

(e) stability of cover systems in above-ground landfills.

The stability analysis should be conducted using the following soil mechanics methods depending upon the shape of the failure surface: (a) failure surface parallel to slope; (b) wedge method of analysis; (c) method of slices for circular failure surface and (d) special methods for stability of anchored geomembranes along slopes.

In preliminary design of a landfill section, the following slopes may be adopted:

(a) Excavated soil slopes (2.5 Hor : 1 Vertical)

(b) Temporary waste slopes (3.0 Hor : 1 Vertical)

(c) Final cover slopes (4.0 Hor : 1 Vertical)

Slopes can be made steeper, if found stable by stability analysis results. Acceptable factors of safety may be taken as 1.3 for temporary slopes and 1.5 for

permanent slopes. In earthquake prone areas, the stability of all landfill slopes will be conducted taking into account seismic coefficients as recommended by BIS codes.

17.6.16 Materials Balance

A materials balance should be prepared for each material required for construction of a landfill, phase-by-phase, indicating materials required, materials available and deficient material to be imported or surplus material to be exported. If a borrow area is located within the landfill site it should not become a part of an early phase to avoid stockpiling and double handling.

17.6.17 Site Infrastructure

The following site infrastructure should be provided:

(a) Site Entrance and Fencing

(b) Administrative and Site Control Offices

(c) Access Roads

(d) Waste Inspection and Sampling Facility

(e) Equipment Workshops and Garages

(f) Signs and Directions

(g) Water Supply

(h) Lighting

(i) Vehicle Cleaning Facility

(j) Fire Fighting Equipment.

Site entrance infrastructure should include:

(a) a permanent, wide, entrance road with separate entry and exit lanes and gates.

(b) sufficient length/parking space inside the entrance gate till the weighbridge to prevent queuing of vehicles outside the entrance gate and on to the highway. A minimum road length of 50 m inside the entry gate is desirable

(c) A properly landscaped entrance area with a green belt of 20 m containing tree plantation for good visual impact

(d) Proper direction signs and lighting at the entrance gate

(e) A perimeter fencing of at least 2m height all around the landfill site with lockable gates to prevent unauthorised access

(f) Full time security guard at the site.

An accurate record of waste inputs is essential. Twin weighbridges to weigh both entry and exit weights may be located on either side of an island on which a weighbridge office room is located. The weighbridge should be located well inside the entrance gate to avoid congestion and queuing at the gate. The weighbridge office should be elevated and the weighbridge operation should be able to see entering vehicles as well as speak to drivers. Raised platforms weighbridges with computerised output and with facility for manual recording of displayed readings are recommended. Such weighbridges should remain operative during power supply failure.

Administrative and site control offices should include: administrative office building (permanent); site control office (portable) near the active landfill area; stores (permanent) within or near administrative office; welfare facilities – toilets, shower room, first aid room, mess room, small temporary accommodation; infrastructural services – electricity, drinking water supply, telephone, sewerage and drainage system and communication services (telephone etc.) between site control office and administrative office and weighbridge office.

The provision of well maintained, high quality site roads is necessary to ensure the free flow of traffic and a fast turn around of vehicles. The construction details of three types of roads are required: main access road (permanent); arterial road (permanent) and temporary road.

17.6.18 Landfill Equipment

The following equipment is required at a landfill site:

(a) Dozers – for spreading waste and daily cover

(b) Landfill Compactors – for compaction of waste

(c) Loader Backhoes – for loading of waste (internal movement), for excavating trenches etc., for embankment construction

(d) Backhoes and front end loaders (instead of (c) above)

(e) Tractor trailors – for internal movement of waste or daily cover soil

(f) Poclains or heavy duty backhoes for large excavation and embankment construction

(g) Soil compactors – sheepsfoot rollers and smooth steel drum rollers (for finishing passes)

The recommended numbers of each type of equipment required at a landfill is indicated in Table 17.4.

TABLE 17.4 : EQUIPMENT AT LANDFILLS

Waste Received At Landfill per day	**Buldozers**	**Loaders**	**Excavators**	**Compactors**	**Water tankers**	**Tractor Trailers/ Tippers**
upto 200 tons	2	2	2	2	1	2
200 to 500 tons	3	3	3	3	1	4
500 to 1000 tons	5	4	3	5	2	6

(a) Productivity of each equipment should match waste handling per day in 8 hour shift or earthwork handling per day in 8 hour shift with atleast one standby equipment.

(b) Loader - Backhoes can be purchased to perform the functions of loaders and excavators.

(c) Compactors are steel wheeled compactors with cleated/spiked wheels having operating weight ranging from 12 tons to 30 tons. These should be equipped with a trash blade.

17.6.19 Design of Environmental Monitoring System

The objective of an environmental monitoring system is (a) to find out whether a landfill is performing as designed; and (b) to ensure that the landfill is conforming to the regulatory environmental standards.

Monitoring at a landfill site is carried out in four zones: (a) on and within the landfill; (b) in the unsaturated subsurface zone (vadose zone) beneath and around the landfill; (c) in the groundwater (saturated) zone beneath and around the landfill and (d) in the atmosphere/local air above and around the landfill.

The parameters to be monitored regularly are:

(i) leachate head within the landfill;

(ii) leachate and gas quality within the landfill;

(iii) long-term movements of the landfill cover;

(iv) quality of pore fluid and pore gas in the vadose zone;

(v) quality of groundwater in the saturated zones and

(vi) air quality above the landfill, at the gas control facilities, at buildings on or near the landfill and along any preferential migration paths.

The indicators of leachate quality and landfill gas quality must be decided after conducting a study relating to the type of the waste, the age of the waste, the composition of leachate and gas likely to be generated and the geotechnical as well as hydro-geological features of the area. Typical leachate and gas constituents have already been indicated in sections 17.6.6 and 17.6.10. All monitoring programmes must first establish the baseline/background conditions prior to landfill monitoring.

The frequency of monitoring will vary from site to site but it must be so fixed that it is capable of detecting unusual events and risks in the initial phases of their appearance so as to give time to diagnose and localise the cause and enable early steps to be taken for containment or remediation. Usually a monthly or a bi-monthly monitoring frequency is considered suitable during the operational phase of a landfill as well as for 3 to 4 years after closure; this frequency can be decreased to 2-3 times a year in later years, if all systems perform satisfactorily. The monitoring frequency may have to be increased if higher concentrations than expected are detected, if control systems are changed or if drainage systems become clogged/non-functional. The frequency of monitoring may also be increased during those periods in which gas generation or leachate generation is higher, such as during the monsoon periods.

A monitoring programme must specify (i) a properly selected offsite testing laboratory capable of measuring the constituents at correct detection levels, (ii) a methodology for acquiring and storing data; and (iii) a statistical procedure for analyses of the data.

The following instruments/equipment will be used for monitoring (Fig. 17.25):

(a) Groundwater samplers for groundwater monitoring wells

(b) Leachate samplers for leachate monitoring within the landfill and at the leachate tank

(c) Vacuum lysimeters, filter tip samplers, free drainage samplers for leakage detection beneath landfill liners.

(d) Surface water samplers for collection of sample from sedimentation basin.

(e) Downhole water quality sensors for measuring conductivity, pH, DO, temperature in leachate wells, groundwater wells and sedimentation basins.

(f) Landfill gas monitors (portable) for onsite monitoring of landfill gases.

(g) Active and Passive air samplers for monitoring ambient air quality.

It is recommended that the location of each type of instrument/equipment be finalised in conjunction with an expert on the basis of the topography of the area and the layout of the landfill. A minimum of 4 sets of ground water monitoring wells (one up-gradient and three down gradient) for sampling in each acquifer are considered desirable at each landfill site (Fig. 17.26).

17.6.20 Closure and Post-Closure Maintenance Plan

Determination of the end-use of a landfill site is an essential part of the plan for landfill closure and post-closure maintenance. Some possible uses of closed landfill sites near urban centres include parks, recreational areas, golf courses, vehicle parking areas and sometimes even commercial development.

A closure and post-closure plan for landfills involves the following components:

- Plan for vegetative stabilization of the final landfill cover.
- Plan for management of surface water run-off with an effective drainage sytem.
- Plan for periodical inspection and maintenance of landfill cover and facilities.

These aspects are covered in Section 17.9.

17.6.21 Waste Acceptance Criteria

A waste acceptance criteria must be formulated for each landfill site. Presence of small hazardous waste industries in municipal boundaries, if any, should be taken note of.

The following waste acceptance criteria is suggested:

(a) All waste will be routinely accepted if the truck/tipper carries authorised documents indicating the source of waste. Such waste will be routinely inspected visually at the tipping area in the landfill site.

(b) All waste coming in authorised trucks from non-conforming areas (such as unauthorised colonies with micro-industries) will be visually inspected at waste inspection facilities and sampled randomly. Waste may be rejected if found to contain hazardous material.

(c) Non-hazardous small quantity waste may be accepted from industrial zones if certified as non-hazardous by the regulatory authority (Pollution Control Board) and if the quantity is less than 10% of the MSW waste received daily.

(d) All waste rejects from thermal and biological processing of MSW waste will be accepted at the landfill provided it is certified that no additives have been added during the waste processing which render the rejects as hazardous.

(e) Liquid wastes and sludges with high water content will not be accepted at MSW landfill sites.

(f) Dewatered sludges duly certified as non-hazardous will be accepted at landfill sites provided they are less than 10% of MSW received daily.

(g) Ash from incinerators of biomedical waste or industrial waste will not be accepted unless certified as being 'non-hazardous' by the regulatory authority; otherwise it will be disposed in hazardous waste landfill.

(h) Large quantity non-hazardous industrial solid waste (more than 10% of MSW generated daily) should not be accepted at a MSW landfill (or should be stored in separate cells/phases).

(i) Construction and demolition debris be accepted for daily cover requirements or for storage in separate cells/phases in a landfill.

17.7 DESIGN AND CONSTRUCTION OF LANDFILL LINERS

The liner system at the base and sides of a landfill is a critical component of the landfill which prevents ground water contamination. The recommended minimum specification of such a liner is discussed in Section 17.6.7. Design and construction procedures of two elements of the liner system – the compacted clay/amended soil and the geomembrane – are discussed hereafter.

17.7.1 Compacted Clays and Amended Soils

The selection of material to be used a soil barrier layer will usually be governed by the availability of materials, either at site or locally in nearby areas. The hierarchy of options will usually be as follows:

(a) Natural clay will generally be used as a mineral component of a liner system where suitable clay is available on site or nearby.

(b) If clay is not available, but there are deposits of silts (or sands), then formation of good quality bentonite enhanced soil/amended soil, may be economical.

Compacted Clays: Wherever suitable low permeability natural clay materials are available, they provide the most economical lining material and are commonly used. The basic requirements of a compacted clay liner is that it should have permeability below a pre-specified limit (10^{-7} cm/sec) and that this should be maintained during the design life. Natural clay available in-situ is usually excavated and re-compacted in an engineered manner. If clay is brought from nearby areas, it is spread in thin layers and compacted over the existing soil. The quality of the in-situ clay may be good enough to preclude the requirement of a compacted clay liner, only if it has no dessication cracks and is homogeneous as well as uniformly dense in nature.

Amended Soils: When low-permeability clay is not available locally, in-situ soils may be mixed with medium to high plasticity imported clay, or commercial clays such as bentonite, to achieve the required low hydraulic conductivity. Soil-bentonite admixtures are commonly used as low permeability amended soil liners. Generally, well-graded soils require 5 to 10 percent by dry weight of bentonite, while uniformly graded soils (such as fine sand), may typically require 10 to 15 percent bentonite. The most commonly used bentonite admixture is sodium bentonite. Calcium bentonite may also be used, but more bentonite may be needed to achieve the required permeability, because it is more permeable than sodium bentonite.

It is not necessary that the bentonite should be the only additive to be considered for selection. Medium to high plasticity clays from not too distant areas, can also be imported and mixed with the local soils. Usually high quantities of clays (10 to 25 percent) are required to achieve the required permeability. Nevertheless, these may sometimes prove to be more economical than bentonite amended soils and their permeabilities may not be significantly influenced by leachate quality.

17.7.1.1 Specifications

A competent barrier made of compacted soils - clays or amended soils - is normally expected to fulfil the following requirements:

(a) hydraulic conductivity of 10^{-7} cm/sec or less;

(b) thickness of 100 cm or more;

(c) absence of shrinkage cracks due to desiccation;

(d) absence of clods in the compacted clay layer;

(e) adequate strength for stability of liner under compressive loads as well as along side slopes; and

(f) minimal influence of leachate on hydraulic conductivity.

Clays of high plasticity with very low values of permeability (usually well below the prescribed limit), exhibit extensive shrinkage on drying, as well as tend to form large clods during compaction in the relatively dry state. Their permeability can also increase on ingress of certain organic leachates. Well compacted inorganic clays of medium plasticity, either natural or amended, appear to be most suitable for liner construction.

According to various investigators, soils with the following specifications would prove to be suitable for liner construction: Percentage fines - between 40 and 50%; plasticity index - between 10 and 30%; liquid limit - between 25 and 30%; clay content - between 18 and 25%. It is necessary to perform detailed laboratory tests and some field trial tests prior to liner construction to establish that the requirements pertaining to permeability, strength, leachate compatibility and shrinkage are met.

17.7.1.2 Design Process

The design process for a compacted soil liner consists of the following steps:

(j) Identification of borrow area or source of material - in-situ or nearby.

(ii) For in-situ soils, conducting field permeability tests to assess suitability of the natural soil in its in-situ condition.

(iii) Laboratory studies on liner material (from in-situ or nearby locations), comprising of soil classification tests, compaction tests, permeability tests, strength tests, shrinkage tests and leachate compatibility tests.

(iv) Identification of source of additive, if natural soil does not satisfy liner requirements - natural clay from not too distant areas or commercially available clay such as bentonite.

(v) Laboratory studies (as detailed in (iii) above) on soil- additive mixes using different proportions of additive to find minimum additive content necessary to achieve the specified requirements.

(vi) Field trial on test pads, to finalise compaction parameters (layer thickness, number of passes, speed of compactor), as well as to verify that field permeability of the compacted soil lies within pre-specified limits.

17.7.1.3 Laboratory Studies

For amended soils, the following tests should be conducted to arrive at the minimum additive content.

Additive Composition: Grains size distribution, plasticity tests and mineralogy tests, are performed to identify the clay content, activity and clay mineralogy of the additive.

Host Material Composition: Grain size distribution and plasticity tests are performed on the host material, to assess that the host material will mix readily with the additive. Clean sands, silty sands and non-plastic silts, usually mix readily with clays and bentonites. Cohesive hosts are more difficult to mix due to balling effect yielding uneven mixing. The host material must be sufficiently dry for proper mixing.

Soil-Additive Compaction Tests: Standard Proctor (or modified) tests are undertaken with variable quantities of additives mixed to the soil, usually in increments of 2 to 5 percent. The influence of the additive on dry density and optimum moisture content are evaluated [Fig. 17.27(a)].

Soil-Additive Permeability Tests: Permeability tests are conducted on as-compacted-then-saturated samples of amended soil with different percentages of additive, each sample compacted to maximum density at optimum water content. The hydraulic conductivity usually decreases with increasing additive content (Fig. 17.27(b)). It is possible to identify a minimum additive content, from a series of tests, which may be required to achieve the desirable hydraulic conductivity.

Analysis of Laboratory Results: Field engineers usually require a compaction specification, which states the minimum acceptable dry density as well as the acceptable range of water content. It is usually possible to arrive at a narrow

acceptable range of water content and dry density as shown in Fig. 17.28. A step-by-step process of elimination is to be adopted to identify this acceptable range of water content and dry density, which should then be communicated to the field engineer.

17.7.1.4 Field Trial Test Pads

The construction of a field trial test pad prior to undertaking construction of the main liner has many advantages. One can experiment with compaction equipment, water content, number of passes of the equipment, lift thickness and compactor speed. Most importantly, one can conduct extensive testing, including quality control testing and hydraulic conductivity tests, on the test pad. The test pad should have a width which is significantly more than the width of the construction vehicles (> 10 m) and greater length. The pad should ideally be the same thickness as the full-sized liner, but may sometimes be thinner. The in-situ hydraulic conductivity may be determined by the sealed double ring infiltrometer method. In in-situ tests on test pads, the hydraulic conductivity is measured under zero overburden stress. Hydraulic conductivity decreases with increasing overburden stress. The hydraulic conductivity measured on a test pad, should be corrected for the effects of overburden stress, based on results of laboratory conductivity tests performed over a range of compressive stresses.

17.7.1.5 Construction Aspects

Compacted Clays: The typical sequence of construction for compacted clay liners is as follows:

(a) Clearing of borrow area by removal of shrubs and other vegetative growth.

(b) Adjustment of water content in the borrow area - sprinkling or irrigating for increasing the water content and ripping and aerating for lowering the water content.

(c) Excavation of material.

(d) Transportation to site in haulers or through conveyor systems (short distance).

(e) Spreading and levelling of a thin layer (lift) of soil (of thickness about 25 cm).

(f) Spraying and mixing water for final water content adjustment.

(g) Compaction using rollers.

(h) Construction quality assurance testing.

(i) Placement of next lift and repetition of process till final thickness is achieved.

The two fold objectives of soil compaction are (a) to break and remould the clods into a homogeneous mass, and (b) to densify the soil. If the compaction is performed such that the required density at the specified moisture content is obtained, the required permeability will be achieved in the field. Regulations generally require that a minimum 100 cm thick compacted clay liner be constructed. This thickness is considered necessary so that any local imperfections during construction will not cause hydraulic short-circuiting of the entire layer. Compacted soil liners are constructed in a series of thin lifts. This allows proper compaction and homogeneous bonding between lifts. Generally, the lift thickness of clay liners is 25 to 30 cm before compaction and about 15 cm after compaction. It is important that each lift of clay liner be properly bonded to the underlying and overlying lifts. If this is not done, a distinct lift interface will develop, which may provide hydraulic connection between lifts.

Sheepsfoot rollers are best suited for compacting clay liners. Rollers with fully penetrating feet have a shaft about 25 cm long. Unlike partially penetrating rollers (pad-footed rollers), the fully penetrating sheeps foot roller (Fig. 17.29) can push through an entire soil lift and remold it. In addition to increasing bonding between lifts, one should maximize the compactive energy by considering factors such as roller weight, area of each foot, number of passes and the speed of the roller.

The lifts are typically placed in horizontal layers. However, when liners are constructed on the side slopes, the lifts can be placed either parallel to the slope (for slopes up to 2.5 Horizontal:1Vertical, due to limitations of compaction equipment) or in horizontal lifts(Fig. 17.30). Horizontal lifts require a width which is at least the width of one piece of construction equipment (usually 3 to 4 m).

Amended Soils: The process of construction of amended soil liners is similar to that for compacted clay liners with the modification that the additive is introduced into the soil after the excavation stage. Additives such as bentonite can be introduced in two ways - by in-place mixing or by central plant method. In the latter technique, soil and additive are mixed in a pugmill or a central mixing plant. Water can also be added in the pugmill either concurrently with bentonite or in a separate processing step. The central mixing plant method (Fig. 17.31) is more effective than in-place mixing and should be adopted. The use of small truck mounted concrete batching plants for mixing bentonite can also be examined.

The quality of the mix must be checked to ensure uniformity and correctness of the additive. A minimum of five trial runs should be made to check the quality of the mix visually and using grain size analysis. The permeability should also be checked using the field mix, compacted in the laboratory.

17.7.1.6 Construction Control

During construction, quality control is exercised to ensure that the constructed facility meets the design specifications.

Borrow area material control and amended soil control involves the following tests: (a) grain size distribution; (b) moisture content; (c) Atterberg's limits; (d) laboratory compaction tests; and (e) laboratory permeability tests. The frequency of testing varies from one test per 1000 cu.m, to one test per 5000 cu.m.

Compacted soil liner control involves the following tests: (a) in-situ density measurements; (b) in-situ moisture content measurements; (c) laboratory permeability tests on undisturbed samples; (d) in-situ permeability tests; (e) grain size distribution and Atterberg's limits of compacted samples. The frequency of testing for in-situ density and moisture content may be as high as 10 tests/hectare/lift whereas the other tests may be conducted at a lower frequency of about 2 tests/hectare/lift [Sharma and Lewis (1994)].

17.7.2 Geomembranes

A High Density Poly ethylene (HDPE) geomembrane of minimum thickness of 1.5 mm is to be laid over the compacted clay/amended soil with no gaps along the surface of contact.

17.7.2.1 Specifications

The geomembrane is normally expected to meet the following requirements:

(a) it should be impervious

(b) it should have adequate strength to withstand subgrade deformations and construction loads

(c) it should have adequate durability and longevity to withstand environmental loads

(d) the joints/seams must perform as well as the original material.

Typical specifications for geomembrane liners are given in Table 17.5. The specifications are only suggestive and need to be refined by a geosynthetics specialist for each landfill site.

TABLE 17.5 : TYPICAL VALUES FOR GEOMEMBRANES MEASURED IN PERFORMANCE TESTS

S.No.	Property		Typical Value
1	(a)	Thickness	1.5 mm (60 mil)
	(b)	Density	0.94 gm/cc
2.	Roll Width x Length		6.5 m x 150 m
2.	Tensile Strength		
	(a)	Tensile Strength at yield	24 kN/m
	(b)	Tensile Strength at Break	42 kN/m
	(c)	Elongation at Yield	15%
	(d)	Elongation at Break	700%
	(e)	Secant Modulus (1%)	500 MPa
3.	Toughness		
	(a)	Tear Resistance (initiation)	200N
	(b)	Puncture Resistance	480N
	(c)	Low Temperature Brittleness	$-94^{0}F$
4.	Durability		
	(a)	Carbon Black	2%
	(b)	Carbon Black Dispersion	A-1
	(c)	Accelerated Heat Ageing	Negligible strength changes after 1 month at $110^{0}C$
5.	Chemical Resistance		
	(a)	Resistance to Chemical Waste Mixture	10% strength change over 120 days
	(b)	Resistance to Pure Chemical Reagents	10% strength change over 7 days
7.	Environmental Stress Crack Resistance		1500 hrs.
8.	Dimensional Stability		$\underline{+}$ 2%
9.	Seam Strength		80% or more (of tensile strength)

17.7.2.2 Design Aspects

The following components have to be designed/checked for in the case of geomembranes:

(a) anchor trench

(b) sliding along slopes

(c) allowable weight of vehicle

(d) uneven settlement

(e) panel layout plan.

Design details are provided by Bagchi (1994).

17.7.2.3 Construction/Installation of Geomembranes

Although the construction activities for geomembrane installation are not as time consuming as clay liner construction, the quality control tests are intensive. The surface of compacted clay/amended soil must be properly prepared for installation of synthetic membrane. The surface must not contain any particles greater than 1.25 cm (0.5 in.) size. Larger particles may cause protuberance in the liner. The panel layout plan should be made in advance so that travel of heavy equipment on the liner can be avoided. In no case should it be allowed on the liner. Seaming of panels within 1.0 m of the leachate collection line location should be avoided if possible; this issue can be finalized during the layout plan. The subbase must be checked for footprints or similar depressions before laying the liner. The crew should be instructed to carry only the necessary tools and not to wear any heavy boots (tennis shoes are preferred). Laying of the synthetic membrane should be avoided during high winds [24 kmph or more]. Seaming should be done within the temperature range specified by the manufacturer.

Several types of seaming methods are available. The following are some of the commonly used seaming techniques: thermal-hot air, hot wedge fusion, extrusion welding (fillet or lap), and solvent adhesive. The manufacturer usually specifies the types of seaming to be used and in most cases provides the seaming machine. Manufacturer's specifications and guidelines for seaming must be followed. Seaming is more of an art even with the automatic machines. Only persons who are conversant with the machine and have some actual experience should be allowed to seam. For HDPE, hot wedge fusion and extrusion welding type seaming are commonly practised.

Geomembranes must be covered with protective soil as soon as possible. Enough volume of soil should be stockpiled near the site so that it can be spread on the finished membrane as soon as the quality control test results are available and the final inspection is over. Synthetic membranes can be damaged by hoofed animals. Bare membrane should be guarded against such damage by fencing the area or by other appropriate methods.

At least 30 cm of fine sand or silt or similar soil should be spread on the membrane as a protective layer. The soil should be screened to ensure that the maximum particle size is 1.25 cm or less. The traffic routing plan must be carefully made so that the vehicle(s) does not travel on the membrane directly. Soil should be pushed gently by a light dozer to make a path. Dumping of soil on the membrane should be avoided as much as possible. One or two main routes with extra thickness of soil (60-90 cm) should be created for use by heavier equipment for the purposes of soil moving. Even the utmost precaution and quality control during installation will be meaningless if proper care is not taken when covering the membrane. Slow and careful operations are the key to satisfactory soil spreading.

The geomembrane bid specification should include warranty coverage for transportation installation and quality control tests. The cost of a project may increase due to the warranty. The experience of the company (both in manufacturing and installation), quality control during manufacturing and installation, physical installation should be asked in the bid so proper comparisons among different bidders can be made.

17.7.2.4 Quality Control Before and During Geomembrane Installation

Tests of several physical properties of the membrane must be performed before installation. Usually most of these tests are performed at the time of manufacturing in the manufacturer’s laboratory. The owner may arrange for an independent observer to oversee the tests, conduct the tests in an independent laboratory, or use a “split sampling” technique. This issue of responsibility for preinstallation quality control tests must be clearly mentioned or resolved during the biding process. The following are tests used for quality control purposes: (a) sheet thickness, (b) melt index, (c) percentage carbon black, (d) puncture resistance, (e) tear resistance, (f) dimensional stability, (g) density, (h) low-temperature brittleness, (i) peel adhesion, and (j) bonded seam strength.

The quality control tests that are performed during installation include the following:

(a) Inspection of surface of compacted clay/amended soil layer.

(b) Verification of the proposed layout plan.

(c) Check roll overlap.

(d) Checking anchoring trench and sump.

(e) Testing of all factory and field seams using proper techniques over full length.

(f) Destructive seam strength test.

(g) Patch up repair.

17.7.3 Drainage Blanket

A drainage larger is constructed over the protective soil layer placed on a geomembrane. It must have permeability greater than 10^{-2} cm/sec. The 0.074 mm or less fraction content of the drainage blanket material should not be more than 5%. A clean coarse sand is the preferred material for the drainage blanket, however, gravel may also be used for this purpose. When a layer of gravel is used as a drainage blanket; the fines from the waste may migrate and clog the blanket. A filtering medium design approach may be used in designing a graded filter over a gravel drainage blanket.

The quality control tests include tests for grain size analysis and permeability. Usually one grain size analysis for each 1000 cu.m and one permeability test for each 2000 cu.m of material used is sufficient. For smaller volumes a minimum of four samples should be tested for each of the above properties. The permeability of the material should be tested at 90% relative density.

Sand blanket will be placed in leachate collection trenches as specified by the designer of leachate collection pipes.

17.8 CONSTRUCTION AND OPERATIONAL PRACTICE

The construction and operation of a landfill consists of the following steps:

(a) Site Development

(b) Phase Development

(c) Phase Operation

(d) Phase Closure

(e) Landfill Closure

17.8.1 Site Development

The following construction activities are undertaken during site development:

(a) Construction of perimeter fence and entrance gate

(b) Construction of main access road near the entrance gate with parking area

(c) Construction of main access road along the perimeter of the site and well as construction of arterial load to tipping area of the first phase

(d) Acquisition and installation of weighbridges

(e) Construction of weighbridge room/office; administrative office and site control office

(f) Construction of waste inspection facility, equipment workshop and garage, vehicle cleaning area

(g) Installation of direction signs, site lighting, fire fighting facilities, communication facilities

(h) Construction of water supply and waste water/sewage disposal system

(i) Construction of surface water drainage system

(j) Construction of main leachate pipe, tank and treatment facility

(k) Installation of environmental monitoring facilities

(l) Construction of gas collection pipe and treatment facility.

17.8.2 Site Procedures

It is important to formalise and document the record keeping procedures as well as waste acceptance procedures to be followed at the landfill site.

17.8.2.1 Record Keeping

Records will be kept on a daily, weekly and monthly basis. In addition a Site Manual will be kept at the site office giving all site investigation, design and construction details – these are necessary as landfill design may get modified during the operational phase.

Site Manual: The site manual will contain the following information:

(a) Data collected during site selection

(b) Environmental impact assessment report

(c) Site investigation and characterisation data

(d) Detailed topographical map

(e) Design of all landfill components

(f) Landfill layout and its phases

(g) Construction Plans

(h) Details of Leachate Management Plan

(i) Details of Gas Management Plan

(j) Environmental Monitoring Program

(k) Closure and Post-Closure Plan

(l) All permissions/licences from concerned authorities.

Site Reports: The daily, weekly and monthly reports will comprise of the following:

(a) Weighbridge data (daily inflow and outflow for each vehicle)

(b) Waste inspection data (daily)

(c) Materials, stores etc. (daily)

(d) Bills/accounts (daily)

(e) Visitor record (daily)

(f) Complaints record from nearby areas (daily)

(g) Topographic survey at operating phase (daily/weekly)

(h) Photographic record at operating phase (daily/weekly)

(i) Environmental monitoring data (weekly/monthly)

(j) Wastefilling plan and actual progress i.e. cell construction (daily/weekly) and review (monthly)

(k) Leachate generation and gas generation (weekly/monthly/extreme events)

(l) Weather/climatic data (extreme events)

(m) Accidents etc. (adhoc)

(n) Others

17.8.2.2 Waste Inspection Procedure

Each vehicle carrying the waste must be checked for:

(a) Incoming weight (full)

(b) Outgoing weight (empty)

(c) Availability of relevant documents

(d) Visual check at weigh-in (if feasible)

(e) Visual inspection after discharge at tipping area (inspection report to be filed for each vehicle). A visual inspection checklist must be framed which should list visual features for identification of unacceptable material. This checklist must be filled for every unloading by a vehicle in tipping area at the working phase in the landfill.

If there is reason to doubt the presence of unacceptable waste, the vehicle will be taken to the waste inspection facility, the waste down-loaded, inspected visually and sampled (if necessary). Vehicles having non-conforming waste will be held-up and matter reported to engineer or manager at site.

17.8.3 Phase Development

Development of each phase is done is stages. These stages are:

(a) Clearing the area of all shrubs and vegetation,

(b) Excavation (if required),

(c) Stockpiling of excavated material and material imported from borrow area,

(d) Levelling of base and side slopes of landfill and achieving desirable grades at the base of the landfill,

(e) Construction of embankment and temporary terms along the perimeter of the phase,

(f) Construction of temporary surface water drains,

(g) Installation of monitoring instruments,

(h) Liner construction,

(i) Leachate collection and removal system.

17.8.4 Phase Operation

At the design stage the phases of a landfill are clearly demarcated. Operation of a phase requires planning and execution of daily activities – daily waste filling plan and demarcation, waste discharge and inspection, waste placement, waste compaction, daily covering of waste, prevention of pollution and fires.

17.8.4.1 Daily Waste Filling Plan and Demarcation at Site

On the completion of a phase and before the start of a new phase, a waste filling plan for daily cells must be evolved (Fig. 17.32). A study of the landfill base contour maps and the final cover levels of the phase allows such a plan to be developed. If a phase is to be operational for 365 days, all 365 cells must be marked in plan and in sectional drawings. These may require revision as a landfill is constructed because waste quantities may vary in an unforeseen manner.

The area and height proposed to be filled every day should be demarcated at the site on a daily or weekly basis using temporary markers or bunds.

17.8.4.2 Waste Discharge and Inspection

Waste must be discharged by tipping at the working area of a landfill, within the area demarcated for the cell. Every discharged load should be visually inspected by a designated operator. Working area personnel should be trained and competent at waste identification in order that they can recognise waste which may be non-conforming. In the event of reasonable doubt as to the waste acceptability, the operator should inform the waste reception facility and/or the site manager immediately and the consignment should be isolated pending further inspection.

17.8.4.3 Waste Placement (Spreading)

Once waste has been discharged it must be spread in layers and compacted in a well defined manner to ensure that the completed slopes of a daily cell are at the designed gradients.

Waste placement (spreading) can be done by the following methods (Fig. 17.33):

(a) Face tipping method: Waste is deposited on top of existing surface and spread horizontally by tipping over an advancing face.

(b) Inclined layering method (onion skin tipping): Similar to (a) but inclined layering (gentle slope) done instead of advancing of face.

(c) Working upwards: Waste is deposited on the lower surface and pushed upwards.

17.8.4.4 Waste Compaction

It has become conventional practice to level and compact the waste as soon as it is discharged at the working area. Steel wheeled mobile landfill compactors (cleated/spiked/ special wheels) are generally accepted as the best equipment for this purpose. They have largely replaced the small crawler-tracked machines which previously were in general use. These steel wheel compactors have been developed specifically for landfill operations with different patterns of cleated wheels designed to break up and compact waste. For small sites receiving low volumes of waste, a compactor alone may be adequate to spread and compact the waste as well as handle and place cover material. However, a compactor is not designed to be a multi-purpose machine and at busy sites it is more usual to provide a tracked dozer or wheeled bucket loader for spreading followed by a compactor for densification. Compactors help to (a) chop and homogenise the waste; (b) reduce the void fraction of the waste; (c) produce an even and stable surface; and (d) pin down waste to minimise litter and make the site less attractive to birds and vermin.

Landfill compactors are not manufactured in India. However, they are available overseas in a wide range of sizes and operating weights (typically ranging from 12 tons to 30 tons). Apart from size, the differences between machines are the cleat patterns on the wheels and the wheel configuration. The wheel configuration is relevant when determining the number of passes required to achieve the desired amount of compaction.

17.8.4.5 Daily Cover

The advantages of using daily cover are primarily in preventing windblown litter and odours, deterrence to scavengers, birds and vermin and in improving the site's visual appearance. It is also advocated as a means of shedding surface water during the filling sequence, thereby assisting in leachate management by reducing infiltration, although its effectiveness in this respect is doubtful.

It is important that site location and waste inputs are taken into account when considering the type and application of daily cover. Soils used as daily cover will give a pleasing uniform appearance from the site boundary. To achieve this a thickness of about 150 mm is usually adequate and should be adopted. About 300 m.m. needs to be used to avoid paper, etc being seen from close proximity. This is excessive for other purposes and the visibility of waste through daily cover should not be regarded as the sole criterion of effectiveness.

At sites where daily covered is spread by machines such as dozers etc., a thickness less than 150 mm will not be feasible, keeping in view the uneven surface of the waste. At sites where daily cover is spread manually, a thickness of 100 mm can be attempted if soil is used; this thickness should not be less than 150 mm if construction debris is used.

Cover material takes up valuable void space for primary wastes and if a 150 mm deep layer is placed over every 2 m layer of waste, about 7.5% of the void space is lost. The covering of faces and flanks will cause even more less of void space and most operators estimate that the total loss of void space is between 10% and 20%.

If compacted, daily cover can have a relatively low permeability which results in the partial containment of each layer of waste. As a result leachate becomes perched and difficult to extract. Landfill gas then moves preferentially sideways giving greater potential for migration off-site and both gas and leachate become difficult to extract. Hence daily cover way not be compacted by rollers.

Traditionally soil material has been used for daily cover. Whenever possible daily cover is obtained by planned excavation from within the landfill area and thereby causes no net consumption of space. This will optimise the commercial value of the waste accepted. Where a site is deficient in appropriate resources, daily cover may come through the gate from construction activities. Construction waste is now also used to form screening bunds and for landscaping at the construction site.

Results so far have failed to identify any single material which can be used as a simple substitute for soil materials and all of them have given rise to secondary problems.

17.8.4.6 Pollution Prevention During Operation

Measures are needed to ensure that the landfill operation does not adversely affect local environment within and outside the landfill. Operators may appoint community liaison officers to be available to visit complainants and establish the nature and source of the problem. This is reported to the site manager so that corrective measures can be taken.

Traffic: Heavy lorry traffic can give rise to nuisance, damage to road surface and verges and routing problems. The following guidelines are helpful:

(a) routing to avoid residential areas

(b) using one-way routes to avoid traffic conflict in narrow roads

(c) carrying out road improvements, for example strengthening or widening roads, improved provision of footpaths, improvement of sight lines, provision of passing places, provision of new roads

(d) Limiting the number of vehicle movements

(e) Restrictions on traffic movement hours which are staggered with respect to peak traffic hours.

Noise: Adverse impacts on the local community from noise may arise from a number of sources including - throughput of vehicles and fixed and mobile plant, for example compactors, generators at the site. Peripheral noise abatement site measures should be adopted.

Odour: Offensive odours at landfill sites may emanate from a number of sources, including waste materials, which have decomposed significantly prior to landfilling, leachates and leachate treatment systems, and landfill gas.

Good landfill practices will greatly reduce general site smell and reduce impact from odours which could lead to complaints from the local community, site users and site staff. Good practice includes: (a) adequate compaction; (b) speedy disposal and burial of malodorous wastes; (c) effective use of appropriate types of daily cover; (d) progressive capping and restoration; (e) effective landfill gas management; (f) effective leachate management and (g) consideration of prevailing wind direction when planning leachate treatment plants, gas flares, and direction of tipping.

Litter: Poor litter control both on and off site is particularly offensive to neighbours. Good operational practice should be adhered to in terms of waste discharge, placement, compaction and covering to minimise the occurrence of windblown litter. Measures for controlling litter include:

(a) consideration of prevailing wind direction and strength when planning the filling direction and sequence

(b) Strategically placed mobile screen close to the tipping area or on the nearest downwind crest

(c) Temporary banks and bunds immediately adjacent to the tipping area

(d) Permanent catch fences and netting to trap windblown litter

(e) Restricting incoming vehicles to only those which are sheeted and secured will reduce litter problems on the highways.

Litter pickers should be employed to collect litter which escapes the preventative measures. Litter screens, fences, nets and perimeter ditches should be maintained free of litter.

Bird Control: Birds are attracted to landfill sites in large numbers, particularly where sites receive appreciable amounts of food wastes. Usually only large birds such as eagles, gulls are regarded as a nuisance. Bird control techniques should be carefully planned taking into account the species likely to be affected. Measures which can be used to mitigate bird nuisance include the employment of good landfill practice, working in small active areas and progressive prompt covering of waste, together with the use of bird scaring techniques. Measures involving explosions or distress calls have inherently adverse environmental impacts in terms of noise.

Vermin and Other Pests: Landfills have potential to harbour flies and vermin, particularly where the waste contains food materials. Modern landfilling techniques including prompt emplacement, consolidation and covering of wastes in well defined cells are effective in the prevention of infestation by rodents and insects. Rats and flies are the main pests which require control. Sites with extensive non-operational land can become infested with rabbits.

Effective measures to deal with rodent infestation include regular visits by pest control contractors or fully trained operatives. The use of insecticides on exposed faces and flanks of the tipping area, by spraying and fogging, is an effective means of exterminating insects.

Dust: Dust from landfill operations is mainly a problem during periods of dry weather but can also arise from dusty waste as it is tipped. Dust is generally associated with (a) site preparation and restoration activities; (b) the disposal of waste comprising of fine particles, for example powders; and (c) traffic dust. Dust suppression can be effected by (a) limiting vehicle speed; (b) spraying roads with water; and (c) spraying site and powder type waste with water.

Mud on the Road: Mud on the public highway is one of the most common causes of public complaint. It is, therefore, in the interests of the landfill operator to provide adequate wheel cleaning facilities to ensure that mud is not carried off site by vehicles.

17.8.4.7 Landfill Fire Management

Fires in waste on landfill sites are not uncommon and it is important for site operators to be aware of the dangers, how to treat fires and to address the problems associated with them. All fires on-site should be treated as a potential emergency and dealt with accordingly.

All sites should have an emergency tipping area set aside from the immediate working area where incoming loads of material known to be on fire or suspected of being so can be deposited, inspected and dealt with.

Waste that is burning on delivery should be doused with water or more preferably covered progressively with adequate supplies of damp soil/cover followed by cooling and finally removal to its disposal point. It should not normally be allowed to burn itself out as this will give rise to nuisance from smoke and odour and may constitute a health risk. Fire fighting techniques should be appropriate for the waste type.

Fires within the operational area are either surface fires or deep-seated fires. The former usually occur in recently deposited and as yet uncompacted materials adjacent to the current working area, whilst the latter are found at depth in material deposited weeks or months earlier. Site operators should have a plan to deal with each type of fire and have a code of practice for their operators stating exactly how to tackle any outbreak. Regardless of the circumstances, no individual should ever tackle a landfill fire alone. Deep-seated fires require expensive remediation techniques including vertical cut-offs.

17.8.4.8 Landfill Safety Aspects

Training of employees should include site safety, first aid and the handling of dangerous materials where appropriate. Since landfill sites can pose dangers to both site operator and users, emergency plans should be laid down. Landfill sites should be regarded as potentially hazardous locations and the operator should have a written safety plan for the site.

Safety hazards present at landfill sites may include: (a) moving plant and vehicle; (b) steep slopes; (c) bodies of standing water; (d) contaminated, putrescible, toxic, flammable or infective material and (e) noxious, flammable, toxic or hazardous gas.

All employees and visitors to the site should be made aware of the potential hazards and the safety procedures to be implemented including fire safety.

17.8.5 Phase Closure

After the last set of cells of a phase are placed (on the highest lift), an intermediate or final cover is constructed. If another phase is to be placed over the just completed phase, an intermediate cover is provided. However if the just completed phase has reached the final height of the landfill, the final cover system and surface water drainage system is provided.

An intermediate cover is made of locally available soil (preferably low-permeability) and is 45 to 60 cm thick. It is compacted with smooth steel drum rollers and provided a suitable gradient (3 to 5%) to encourage surface water to run-off from the cover and thus minimise infiltration. The side slopes of the intermediate cover are compacted by the crawler tracked dozer moving up and down the slope.

Final cover construction and quality control issues are similar to those for liner construction and therefore will not be discussed here. The layer below the low-permeability layer, referred to as the grading layer or gas venting layer, should be constructed using poorly graded sand. A grain size analysis for every 400 cu.m of material used is recommended for quality control purposes. The layer should be compacted to above 75% relative density to provide a firm sub-base for the low-permeability layer above. The density should be tested at 30 m grid points.

Laying of the topsoil layer should be done as soon as the protective layer construction is finished. Heavy construction equipment should not be allowed on the finished surface. The nutrient and liming requirements for the topsoil should be assessed from a competent agricultural laboratory. In the absence of a regulatory recommendation/requirement regarding seed mix, a horticulturist or soil scientist should be consulted. A combination of grass and bush type vegetation capable of surviving without irrigation water should be planted (see section 17.9.1). At least five samples of topsoil per hectare (2.4 acres) should be tested for nutrient and liming requirements. Nutrient and seed mix application rates should be supervised on site for quality control purpose. For landfill cover is which gas events are provided extreme are exercised in installation of the vents.

The final cover is provided a gradient of 3 to 5 percent to assist surface run-off. Lined ditches or channels are constructed on the final cover to intercept and carry surface water off the cover to the storm water basin.

On the cover of each phase, settlement devices are installed for monthly measurement of settlement of the landfill cover. This helps in identifying the quantity of soil required periodically for repair of the landfill cover.

17.8.6 Landfill Closure

As each phase is completed and as the final cover level is reached in successive phases, the following interconnectivities are established:

(a) the leachate collection system of each phase is sequentially connected (if so designed)

(b) the surface water drainage system at the cover of each phase is sequentially connected (if so designed)

(c) the temporary surface water drainage system constructed at the base of each completed phase is dismantled.

(d) the gas collection system (if provided) of each phase is sequentially connected.

Upon completion of all phases a final check is made of the proper functioning of all inter connected systems.

An access road is provided on the landfill cover to enable easy approach for routine inspection of the landfill cover.

17.9 POST-CLOSURE STABILISATION, OPERATION AND CARE

17.9.1 Long-Term Vegetative Stabilisation

If a landfill cover is intended to be used for a specific purpose e.g. park or golf course or vehicle parking area, then the cover will be stabilised in such a manner that the end-use is achieved.

However, if no specific end-use is envisaged, then long-term vegetative stabilisation will be undertaken to return the land to its original and natural vegetative landform.

Vegetation is by far the most common and usually the preferred stabilisation option after closure of landfills. If a self-perpetuating vegetative cover can be established, not only can wind and water erosion be minimized, but also the landfill can be returned to some semblance of its original appearance and land use. In favourable climates, re-vegetation may require only modest effort or may occur by natural process during a reasonably short period of time. However, in arid climates or a harsh environment, establishment of vegetation may be a lengthy, difficult and costly process.

Typically, vegetation efforts follow a series of steps. While the specific procedures are unique to each landfill and climatic regime, the following are usually representative elements of the process:

(a) **Seedbed Preparation**: Seedbed preparation is necessary to set the stage for establishment of the short-term community. Initial operations may include grading, furrowing, or grouping to enhance microclimate and addition of nutrients and soil amendments, if required.

(b) **Short-Term Vegetation**: It is common practice, in both humid and dry environments, to rely largely on grasses for the primary initial source of short-term land cover. Usually several species are included in the initial seeding mixture to increase diversity and reduce the chance of total community failure. Short-term vegetation is usually assisted by irrigation.

(c) **Long-Term Vegetation**: To achieved the ultimate goal of attaining a self-sustaining and stable community, a transition between short-term and long-term vegetation must occur. In some cases, this may be left to invasion by native species after short-term vegetation is assured and soil development is well under way. In other cases – for example, when irrigation has been used temporarily to establish the short-term community – it may be necessary or desirable to enhance the natural succession process by replanting with a more diverse mix of species suited to the next stage of community succession, such as shrubs. The need for artificial enhancement of the successional process will depend on the success of previous short-term efforts and on the ultimate intended land use of the reclaimed area. All vegetation efforts, however, should work toward self-generation and minimum management in the long term. Fig. 17.34 illustrates the sequential steps in vegetation growth after landfill closure.

Several factors limit the growth of plants on landfills. These include toxicity of landfill generated gases (methane and carbon dioxide) to root systems, low soil oxygen due to heavy compaction, thin cover layer inhibiting root penetration, low nutrient status of cover soil, high soil temperatures and poor soil structure. Some of these factors can be eliminated or their effect on plant growth reduced. Active gas extraction or proper use of gas barriers with venting system prevent gas migration to the root zone. Waste may be removed from certain areas to enable planting of islands of trees. By separating biodegradable waste from non-biodegradable, it may be possible to create zones free of toxic gases.

17.9.2 Operation after Closure

The following facilities will be operated routinely after closure:

(a) leachate management system;

(b) surface water management system;

(c) environmental monitoring system;

(d) cover rehabilitation and repair system.

The operating methodology will depend on the type of system adopted at the landfill.

17.9.3 Landfill Monitoring

The landfill monitoring programme will be designed and developed as indicated in section 17.6.19.

Quantitative parameter to be monitored will be: (a) leachate quantity; (b) gas quantity; (c) surface water run-off quantity and (d) cover system settlement quantities.

Qualitative parameters to be monitored will be:

(a) leachate quality within the landfill (at the base)

(b) leachate quality after treatment

(c) ground water quality (up gradient and down gradient)

(d) surface water quality at the exit of landfill

(e) gas quality within the landfill

(f) air quality above the landfill and at gas vents

(g) air quality at gas control facilities.

The regulatory limits for various parameters of quality will be prescribed by the regulatory authorities. The monitoring frequency will be as indicated in section 17.6.19.

17.9.4 Periodic Inspection and Maintenance

Periodic inspection and routine maintenance at a closed landfill site should be carried out for a period of 25 years after closure. The following components of a closed landfill are inspected visually after landfill closure to confirm that all functional elements are working satisfactorily. A maintenance schedule with specified reporting formats is drawn up after each inspection.

Cover System: The final cover is inspected 2 to 4 times a year (a) to check that vegetation growth is occurring satisfactorily and that plants are not showing stunted growth, (b) to detect if any erosion gullies have been formed thereby exposing the barrier layers, (c) to earmark depressions that may have developed with time and (d) to identify ponding of water on the landfill cover. At least one inspection should be carried out during or immediately after the peak of the monsoon season.

Closed landfills show significant settlement. Rectification measures must not only re-establish the initial slope of the cover (for proper surface water run-off) but must also ensure that all the components of the landfill cover system continue to perform as originally envisaged. Site managers must have sufficient equipment and funds to periodically carry out maintenance work in the form of soil filling, re-grading the cover and revegetating the landfill cap.

In areas where extensive erosion gully formation is observed, filling of cover material, regarding of cover slopes and revegetation must be routinely undertaken.

Surface Water Drainage System: The surface water drainage system is also inspected 2 to 4 times a year (a) to identify cracks in drains due to settlements, (b) to delineate clogged drains requiring immediate clean-up and (c) to study the level of deposited soil in the storm water basin and initiate excavation measures. Broken pipes and extensively cracked drains may require replacement after filling soil beneath them to establish slopes for gravity flow. In extreme cases where long-term settlement may be excessive, it may become necessary to make sumps and operate storm water pumps for removal of accumulated water in the drainage system.

Gas and Leachate Management Systems: Periodic inspection of the gas and leachate collection systems is undertaken to identify broken pipes, leaking gas (if any) and damaged or clogged wells/sumps. Repair work for gas and leachate management systems requires skilled manpower and should be carried out by the agencies operating the gas treatment and leachate treatment facilities. One may often have to install new gas extraction wells and leachate collection wells if the damaged/clogged facilities are inaccessible and irreparable.

Environmental Monitoring Systems: Ground water monitoring wells, air quality monitoring systems and vadose zone monitoring instruments are periodically inspected to check that all systems are functioning satisfactorily and that well caps and sampling ports are not subjected to damage due to excessive settlement or vandalism.

Environmental monitoring systems have to be maintained during the entire post-closure period as per the requirements of the local environmental regulatory agencies. Wherever possible, monitoring instruments must be periodically re-calibrated. Sampling devices must be routinely detoxified and also regularly checked for proper functioning of the opening and closing of valves or spring loaded mechanisms.

17.10 LANDFILL QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance should be applied at each stage of the landfilling process to ensure that:

(a) the landfill design is of a high standard

(b) effective mechanism are in place to ensure that construction and operation will not deviate from design

(c) documentation is carried out during design, construction, operation, closure, monitoring and post closures care for purposes of satisfying regulations and legal liability.

(d) public has access to and is assured about the acceptability of landfilling quality.

Quality control programmes should be drawn up for all construction and operation related activities and an independent engineer should oversee the implementation of these programme.

Advice may be taken from a Quality Assurance Agency for incorporation of quality control conditions in award of all contracts relating to siting, planning, design, construction, operation, monitoring and maintenance.

17.11 LANDFILLING COSTS

The total cost of landfilling can be broken into the following components:

(a) Initial Costs

- (i) site acquisition cost
- (ii) site selection and environmental impact assessment studies cost
- (iii) site investigation and characterisation costs
- (iv) design and detailed engineering costs (including laboratory studies)
- (v) site development (construction) costs (including infrastructure facilities and leachate/gas treatment facilities)
- (vi) landfill equipment costs (if purchased and not hired).

(b) Operative period-yearly costs (one year phase)

- (i) phase development costs (including liner and leachate collection system costs)
- (ii) phase operation costs
- (iii) phase closure costs
- (iv) interconnectivity of phases costs.

(c) Closure and Post Closure period-yearly costs

- (i) vegetative stabilisation costs
- (ii) operation costs
- (iii) monitoring costs
- (iv) maintenance and Repair costs.

Proper design of phases ensures that initial costs remain low and yearly expenditures remain of the some order of magnitude during operating period and thereafter during post closure periods. The preliminary estimation of landfill costs is indicated in Annexure 17.3.

On the basis of studies conducted at Indian Institute of Technology, Delhi (including the example in Annexure 17.3), it is observed that annual costs for setting up and operating MSW landfills (which have been designed and constructed as per guidelines in this chapter) lie in the range of Rs. 200 to 300 per ton of waste received at the landfill at 1998 prices (land acquisition cost excluded). These costs are similar to those reported for MSW landfills in developing countries in the report "International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management" compiled by UNEP International Environment Technology Centre, Osaka, Japan in 1998 where MSW landfilling costs are indicated to be between US$ 3-10 per ton for low income group countries and between US$ 8-15 per ton for middle income group countries.

17.12 MANPOWER REQUIREMENT

The organisational and administrative structure for municipal solid waste management in a city depends upon the size of the municipal agency. Landfilling activity should be the responsibility of an independent sectional authority which should report directly to the Director/Chief Engineer/Head of Solid Waste Management.

A senior engineer should be incharge of landfilling activity. He should be supported by assistant engineer(s), junior engineer(s), foremen, technicians and workers. The level of the engineer incharge will be dependant on the scale of work (i.e. waste received at the landfill and the following is recommended.

Waste Received at Landfill (tons/day)	Engineer Incharge of Landfilling
Upto 200	Junior Engineer
200 to 500	Assistant Engineer
500 to 1000	Executive Engineer
Above 1000	Superintending Engineer

The number of supporting officers and staff for the engineer incharge should be evaluated as per CPWD norms for earthwork projects of similar magnitude.

17.13 TYPICAL EXAMPLE (PRELIMINARY DESIGN)

A typical example (preliminary design) for MSW generation of 1000 tons per day is given in Annexure 17.2.

17.14 REMEDIATION OF OLD LANDFILL SITES

Old landfill sites will be investigated as indicated in paragraphs (e) and (f) of section 17.1.2. Whenever contamination is observed and is expected to continue, detailed site investigations for remediation will be undertaken and a feasibility study conducted for the choice of appropriate technology. Options such as provision of vertical cut of, impermeable covers, peripheral surface water drains, waste excavation, soil treatment, ground water treatment will be examined.

ANNEXURE 17.1

ESTIMATION OF LANDFILL CAPACITY, LANDFILL HEIGHT, LANDFILL AREA

1. Current Waste generation per year = W (tons per year)
2. Estimated rate of increase (or decrease) of waste generation per year = x (percent)
   (use rate of population growth where waste generation growth rate estimates not available)
3. Proposed life of landfill (in years) = n (years)
4. Waste generation after n years = $W\left(1 + \frac{x}{100}\right)^n$ (tons per year)

5. Total waste generation in n years (T) in tons

$$T = \frac{1}{2}\left[W + W\left(1 + \frac{x}{100}\right)^n\right] n \quad \text{(tons)}$$

6. Total volume of waste in n years (V_w) (on the assumption of 0.85 t/cm.m density of waste)

$$V_w = T/0.85 \text{ (cu.m.)}$$

7. Total volume of daily cover in n years (V_{dc}) (on the basis of 15 cm soil cover on top and sides for lift height of 1.5 to 2 m)

$$V_{dc} = 0.1\, V_w \text{ (cu.m.)}$$

8. Total volume required for components of liner system and of cover system (on the assumption of 1.5m thick liner system (including leachate collection layer) and 1.0 m thick cover system (including gas collection layer)

$$V_c = k\ V_w \quad \text{(cu.m.)}$$

   (k = 0.25 for 10 m high landfill, 0.125 for 20 m high landfill and 0.08 for 30 m high landfill. This is valid for landfills where width of landfill is significantly larger than the height)

9. Volume likely to become available within 10 years due to settlement / biodegradation of waste

$$V_s = m V_w$$

(m = 0.10 for biodegradable waste; m will for less than 0.05 for incinerated/inert waste)

10. First estimate of landfill capacity (C_i)

$$C_i = V_w + V_d + V_c - V_s \quad \text{(cu.m.)}$$

11. Likely shape of landfill in plan and section (To be based on topography of area, depth to ground water table and other factors) :
Area type, trench type, slope type, valley type, combination

12. First estimate of landfill height and area

(a) Restricted area available = A_r (sq.m.)
Area required for infrastructural facilities = 0.15 A_r
Area available for landfilling = 0.85 A_r
Average landfill height required (first estimate) above base level
$H_i = C_i / 0.9\ A_r$ (m) (valid for area type landfill)

(b) No limitation on Area
Possible maximum average landfill height (first estimate) = H_i (typically between 10 to 20 m, rarely above 30 m)
Area required for landfilling seperations

$$A_i = C_I / H_i \quad \text{(sq.m.)} \quad \text{(valid for area type landfill)}$$

Total area required (including infrastructural facilities) (first estimate)

$$A_i = 1.15\ A_i$$

13. Refinement in estimates of landfill capacities, landfill height and landfill area:

After obtaining the initial estimates, the volume of daily cover as well as volume of liner system and cover system can be revised keeping in view the shape of the landfill as well as on the basis of whether materials of daily cover, liner system and cover system will be excavated from within the landfill site.

Taking these revised values into account, refined estimates of landfill capacity, height and area can be made. The final and precise estimates will be arrived at after topographical survey results (0.30 m contour interval) become available.

It may be noted that landfill capacity values will undergo revision during operation of the landfill when waste quantities delivered at the site vary from the generation rates estimated prior to the start of landfill operations.

ANNEXURE 17.2

TYPICAL EXAMPLE (PRELIMINARY DESIGN)

The example given below is applicable for preliminary design of a landfill. Detailed design is not covered in this example. The word 'tentative' is used wherever adequate information was not available and when an adhoc estimate has been made.

17.A2.1 BASIC DATA

Location	:	Delhi
Waste Generation	:	1000 tons per day (current)
Design Life	:	Active Period = 16 years
		Closure and Post Closure Period=25 years
Topography	:	Flat ground
Subsoil	:	Sandy SILT upto 20m below ground surface, underlain by bedrock
Water-table	:	10m below ground surface
Average Total Precipitation	:	750 mm per year
Base year	:	1998 prices

17.A2.2 LANDFILL CAPACITY, LANDFILL HEIGHT, LANDFILL AREA

(a) Current Waste Generation Per Year = 1000 t

(b) Estimated Waste Generation After 16 Years = 1700 t

(c) Total Waste Generation in 16 Years

$= 0.5\ (1000 + 1700) \times 365 \times 16$

$= 7 \times 10^6$ tons

(d) Total Waste Volume (assumed density 0.85 t/cu.m.)

= $(7 \times 10^6)/0.85$
= 8.25×10^6 cu.m.

(e) Volume of Daily Cover

= $0.1 \times 8.25 \times 10^6$
= 0.825×10^6 cu.m.

(f) Volume of Liner and Cover Systems

= $0.125 \times 8.25 \times 10^6$
= 1.03×10^6 cu.m.

= 0.825×10^6 cu.m.

(g) First Estimate of Landfill Volume

Ci = $(8.25 + 0.825 + 1.03 – 0.825) \times 10^6$

= 9.28×10^6 cu.m.

(h) Likely Shape of Landfill

Rectangular in plan (length : width = 2:1)

Primarily above ground level, partly below ground level.

(i) Area Restrictions : Nil

(j) Possible Maximum Landfill Height = 20 m

(l) Area Required = $(9.28 \times 10^6)/20$

= 4.15×10^5 sq.m.

(m) Approximate Plan Dimensions = 450 m x 900 m

(n) Actual Landfill Section And Plan : Discussed in Section 17.A2.3.

17.A2.3 LANDFILL SECTION AND PLAN

(a) Landfill Section and Plan is evaluated on the basis of

(i) 4:1 side slope for the above-ground portion of the landfill.
(ii) 2:1 side slope for the below-ground portion of the landfill.
(iii) Material balance for daily cover, liner and final cover material through excavation at site.
(iv) Extra space around the waste filling area for infrastructural facilities.

(b) The final plan and section adopted is shown in Fig. 17.A2.1.
(c) Additional 30m land is acquired around the landfill to place infrastructure facilities. Final size of landfill = 572 m x 1172 m.

17.A2.4 LANDFILL PHASES

(a) Active life of landfill = 16 years
(b) Duration of one phase = one year
(c) Number of phases = 16. Each phase extends from base to final cover.
(d) Volume of one phase == landfill capacity/16
(e) Plan area of phase
= (Volume of one phase)/landfill height
= 240 m x 120 m (approx.)
(f) Number of daily cells = 365
(g) Plan area of one cell /on the basis of 2.0m lift of each cell
= (Volume of one cell)/2.0
= 22 x 42 m (approx.)

Landfill phases are shown in Fig. 17.A2.2.

17.A2.5 LANDFILL INFRASTRUCTURE & LAYOUT

(a) Site Fencing: All around the landfill

(b) Weighbridges: (computerised) Two weighbridges of 50T capacity (entry and exit) with office

(c) Administrative office: 30 m x 10 m building

(d) Site control office: 3m x 5m (portable cabin)

(e) Access Roads:

(i) Main Access Road : 7m wide; from main road to parking area after weigh- bridge.

(ii) Arterial Road: 3.5 m wide all along the periphery.

(f) Waste Inspection And Sampling Facility: Nil; to be done at landfill area.

(g) Equipment Workshop & Garage: 30m x 20m building

(h) Vehicle Cleaning: Within the Workshop

(i) Other Facilities

(a) Temporary Holding Area: Excavated portion of half phase to be used
(b) Surface water drain: Adjacent to arterial road along periphery
(c) Leachate collection pipe: Adjacent to arterial road along periphery
(d) Leachate holding tank: 20x10x3m
(e) Leachate treatment facility: 40mx20m (in plan) (tentative)
(f) Gas Flaring facility: 20m x 10m (in plan) (tentative)
(g) Surface water sedimentation tank : 40 x 10 x 1.5m

All infrastructural facilities are shown in Fig. 17.A2.3.

17.A2.6 LINER AND LEACHATE COLLECTION SYSTEM

(a) Liner System

The liner system will comprise of the following layers below the waste:

(i) 0.30 m thick drainage layer comprising of Badarpur sand (coarse sand) or gravel (stone dust with no fines)
(ii) 0.2m thick protective layer of sandy silt (Delhi silt)
(iii) 1.50mm thick HDPE geomembrane
(iv) 1.0 m thick clay layer/amended soil layer (since clay is not easily available in Delhi, amended soil layer comprising of local soil + bentonite is to be designed)

(b) Amended Soil Layer Design Through Laboratory Testing

Sandy silt mixed with bentonite in proportions of 2, 4, 6, 8 and 10% in laboratory and permeability determined. Minimum bentonite content determined for achieving permeability of less than 10^{-9} m/sec. 5% Bentonite + sandy silt assumed in preliminary design.

(c) Leachate Evaluation

Average Total Precipitation in Delhi = 750mm/year
Only one phase is operative every year
Plan area of operating phase = 29000 sq.m.
Assuming 80% precipitation in 4 months (monsooon period), peak leachate quantity (thumbrule basis) = 200 cu.m. per day

(d) Leachate Collection Pipes

Dia of HDPE pipes (perforated) = 15 cm
Spacing of pipe required (hydraulic analysis) = 22m

(e) Leachate Holding Tank

Size of holding 3 days of leachate = 20 x 10 x 3 m

Liner system and leachate collection pipes shown in Figs. 17.A2.4 and 5.

17.A2.7 COVER SYSTEM DESIGN

(a) Cover System

The cover system will comprise of the following layer above the waste.

(i) 0.45 m thick gas collection layer comprising of gravel (stone dust with no fines)
(ii) 0.6 m thick barrier layer (sandy silt + 5% bentonite)
(iii) 0.3m thick surface layer of local top soil for vegetative growth

(b) Passive Gas Vents

Passive gas vents 1m high (above ground surface) will be provided at a spacing of 75mx75m.

17.A2.8 SURFACE WATER DRAINAGE SYSTEM

(a) Surface Water Runoff

Average Total Precipitation in Delhi = 750 mm/year

Peak discharge rate reaching drainage channel = 0.064 cu.m./sec.

Dimensions of drainage channel:
Depth = 0.6m, Base width = 0.6m, side slopes = 3:1

(b) Sedimentation Tank

To remove suspended particles of size 40 microns and above tank size required
= 40 x 15 x 1.5

Surface water drainage system depicted in Fig. 17.A2.6.

17.A2.9 ENVIRONMENTAL MONITORING SYSTEM

(a) Ground Water Monitoring Wells

Numbers = 6 (1 upgradient well; 5 wells along the sides in downgradient direction; all wells 30m away from landfill)

(b) Lysimeters

Numbers = 2 lysimeter under each phase. Total nos. = 32.

(c) Gas Monitors

Two portable gas monitors for landfill gas.

(d) Samplers

Stainless steel/HDPE samplers (25 nos.) for
(i) Groundwater samples
(ii) Leachate samples in vertical risers/wells

Grab samplers for landfill gas (25 nos.) at

(i) Passive vents
(ii) Gas wells

(e) Downhole Monitors

One multiparameter downhole groundwater monitoring system.

ANNEXURE 17.3

ESTIMATION OF LANDFILL COST BASED ON PRELIMINARY DESIGN

TABLE 1: SITE SELECTION AND SITE CHARACTERISATION COST

Sl. No.	Item	Cost Rs x 10^5
1.	Data Collection	0.50-0.75
2.	Environmental Impact Assessment	4.00-6.00
3.	Preliminary Bore Holes	1.50-2.25
4.	Geotechnical Investigation for Design , Borrow Material , Ground Water Investigation	7.50-11.25
5.	Topographical Investigation	1.50-2.25
6.	Hydrological Investigation	2.00-3.00
7.	Geological Investigation	2.00-3.00
8.	Traffic Investigation	0.50-0.75
9.	Water and Leachate Investigation	2.00-3.00
	Total	21.50-32.25
	Average	26.88

Note: This estimate is lumpsum and approximate. The values are indicative. However, actual costs will vary from site to site and should not be restricted by the range indicated in the table.

TABLE 2: DESIGN AND DETAILED ENGINEERING COST

Sl. No.	Item	Cost Rs x 10^5
1.	Design and Detailed Engineering	15.00-20.00
	Average	17.50

Note: This estimate is lumpsum and approximate. The values are indicative. However, actual costs will vary from site to site and should not be restricted by the range indicated in the table

TABLE 3: SITE DEVELOPMENT COST

Sl. No.	Item	Cost Rs x 10^5	Cost Rs x 10^5
1.	Land Acquisition*	830.00	
2.	Cost of Infrastructure		102.70
3.	Equipment for Landfill Construction/Operation **	359.00	
4.	Surface Water Drainage System		30.75
5.	Leachate Management Facility		23.85
6.	Environmental Monitoring Facility		8.00
7.	Gas Collection Facility***		
	Total	1189.00	160.30

** Land acquisition cost will vary drastically from location to location; market value indicated but not included in costing.*

*** Equipment cost indicated but not included in costing since all earthwork / waste placement work are computed on job basis.*

**** Not included in the example but to be taken into account whenever gas is collected for energy recovery / flaring.*

TABLE 4: PHASE DEVELOPMENT COST (YEARLY)

Sl. No.	Item	Cost Rs x 10^5
1.	Up-dated Design of Phase	2.00
2.	Preliminary Operation	112.10
3.	Temporary Surface Water Drains	0.80
4.	Monitoring Facility Below Liner	2.00
5.	Liner System	261.85
6.	Leachate Collection and Removal System	8.45
7.	Maintenance of Existing Facility	40.05
	Total	427.25

TABLE 5: PHASE OPERATION COST (YEARLY)

Sl. No.	Item	Cost Rs x 10^5
1.	Waste Filling , Spreading and Compaction	171.30
2.	Daily Cover Laying , Spreading and Compaction	19.45
3.	Pollution Prevention During Operation	4.00
	Total	164.75

TABLE 6: PHASE CLOSURE COST (YEARLY)

Sl. No.	Item	Cost Rs x 10^5
1.	Final Cover System	130.25
2.	Surface Water Drainage System on Cover	10.30
3.	Monitoring Facility on Cover	1.00
4.	Vegetation Growth on Cover	4.40
	Total	175.95

TABLE 7: POST CLOSURE CARE COST (YEARLY)

Sl. No.	Item	Cost Rs x 10^5
1.	Long Term Vegetative Stabilisation	16.00
2.	Operation of Leachate Management Facility	5.00
3.	Maintenance of Cover and Drainage System	12.50
4.	Environmental Monitoring	3.50
	Total	37.00

TABLE 8: INITIAL FIXED COST

Sl. No.	**Item**	**Cost Rs x 10^5**
1.	Site Selection and Site Characterisation Cost (Table 1) Average	21.50-32.25 26.88
2.	Design and Detailed Engineering Cost (Table 2) Average	15.00-20.00 17.50
3.	Site Development Cost (Table 3)	160.30
	Total	204.68

TABLE 9: YEARLY RUNNING COST (ACTIVE)

Sl. No.	**Item**	**Cost Rs x 10^5**
1.	Phase Development Cost (Table 4)	427.25
2.	Phase Operation Cost (Table 5)	164.75
3.	Phase Closure Cost (Table 6)	175.95
	Total	737.95

TABLE 10: YEARLY RUNNING COST (POST CLOSURE)

Sl. No.	**Item**	**Cost Rsx10^5**
1.	Post Closure Care Cost (Table 7)	37.00
	Total	37.00

CHAPTER 18
COMMUNITY PARTICIPATION

18.1. INTRODUCTION

Community is in the centre of all the activities, yet it is ignored by the decision makers and made to merely wait and watch and ultimately what people get in hand is what they do not want or what is not in their priority. This creates a void between the administrators and those administered and an atmosphere of apathy is created which distances people from government initiatives.

Public awareness, effective community participation, transparent and clean administration, introduction of citizen charters and accountability at all levels can only bridge this gap.

Solid Waste Management (SWM) is one such activity, where public participation is key to success. The local body can never be successful in Solid Waste Management without active community participation, whatever may be the investments made from the municipal or Government funds. The local bodies are the institutions of grass root democracy having elected members representing a small group of electorate. It also has an outreach service at the ward level through which it can easily interact with the people on almost all-important issues. The local body should therefore, seriously consider involving community in all programmes through a consultative process and variety of other communication approaches dealt with in this chapter later and adopt the strategy which has the acceptance of the community.

18.2. STRATEGY OF COMMUNITY PARTICIPATION

The following strategy may be adopted by the Urban Local Bodies (ULBs).

18.2.1 Identification of Groups of People to be Addressed.

18.2.1.1 Residential Areas

Community may be classified into three categories

1. High Income Group - the affording

2. Middle Income Group - educated, sensitive, less affording
3. Low Income Group – un-affording

None of the above categories of people is an exception in apathy towards SWM but the level of awareness and sensitivity of each group is different and needs to be tackled differently.

18.2.1.2 Markets/Commercial Areas/Offices/Banks etc.

These places may be classified into three broad categories:-

1. Vegetable Markets
2. Shopping areas
3. Offices/Institutional areas

18.2.2 Identification of the Areas in Solid Waste Management Where Community Participation is Essential

Solid Waste Management involves several stages of activities where people's participation is critically required in some of them and local body has to do the rest of the work.

18.2.2.1 People's Participation is Essential in the Following Areas

1. Reduce, Reuse & Recycling (R R R) of waste.
2. Not to throw the waste/litter on the streets, drains, open spaces, water bodies, etc.
3. Storage of organic/bio-degradable and recyclable waste separately at source.
4. Primary collection of waste
5. Community storage/collection of waste in flats, multi-storied buildings, societies, commercial complexes, etc.
6. Managing excreta of pet dogs and cats appropriately.
7. Waste processing/disposal at a community level (optional)
8. Pay adequately for the services provided.

18.2.3 Reach the Community

The local body should decide the methodology to be adopted for reaching the community and seeking their cooperation and effective participation in SWM services. This is a very difficult area of activity and unless this is done meticulously, desired results will not be achieved.

The essential steps in this direction is to select representative samples of the community and go through a consultative process to ascertain the perceptions of the people about the SWM services being given to them, their expectations and extent to which they are willing to support and participate in the process. Their choice of technological options available also needs to be ascertained.

The consultative process could be taken up as under: -

18.2.3.1 Identification of Problems

Identification of problems of waste management through site visits and consultation with local population at the time when the community is generally available for interaction. It may either be in early morning or late evening. The areas may be selected by following the method of drawl of representative samples.

Situation analysis may be done by the persons who know the subject reasonably well, know local language and can communicate with local population effectively. Such persons may be Non-Governmental Organisations, Community Based Organisations or knowledgeable individuals. They should try to find out the prevalent situation of waste management in the area under observation and ascertain the perceptions of the people about the services provided. In this exercise the local councilors, local leaders, NGOs, etc., may be invited to participate.

18.2.3.2 Finding out Optional Solutions

Having identified the deficiencies in the system and known the public perceptions, the next essential step is to think of optional solutions to tackle the problems, workout the cost implications and level of public participation needed.

18.2.3.3 Consult Community on Options Available

Having done this homework, there should be second round of consultative process where the options worked out may be discussed with the community along with cost implications and their support required. Their suggestions may be sought on each solution proposed. The community may be encouraged to give their views freely.

If we ask the people straight away the solutions of the problems they may not be able to give right kind of suggestions as they have no exposure of various technological options. They must, therefore, be first appraised of the options available and then asked to give their considered opinion on what will work in their area and how much they are willing to cooperate.

18.2.3.4 Workout the Strategy of Implementation

After the consultative process, strategy for implementation of the system may be worked out and pilot projects may be taken up in the areas where better enthusiasm is noticed and demonstrate the successes to other areas and gradually implement in rest of the areas of the city/town. It is desirable to implement the new program in a few areas to begin with, monitor its success carefully and extend the program to other areas thereafter with suitable modifications wherever necessary.

18.3. SYSTEM OF WASTE MANAGEMENT TO BE ADOPTED

Having gone through the consultative process as indicated above, in a few selected areas and having taken up pilot projects, the local body should finally decide on the systems of waste management to be adopted in the city and take the following measures to ensure public participation.

18.3.1 Public Information, Education, Communication Programs (IEC)

For the successful implementation of any program involving public at large in SWM system, it is essential to spell out clearly and make them known the manner in which local body proposes to tackle the problem of waste management and extent to which public participation in Solid Waste Management is expected to keep the city clean and improve the quality of life in the city.

Dayal Committee of Government of India (Report 1995) has advocated that IEC approach should

- Ensure that the people become aware of the problems of waste accumulation and the way it affects their lives directly.
- Ensure that the people generate less waste by cutting back on waste generating material and by following clear defined practices of waste management.

- Create public awareness against big waste generators and provide information to monitor the performance of these sources of waste.
- Inform the people about waste management program of the government and municipal bodies.
- Promote public participation in waste management efforts through private partnership where feasible.
- Propagate the message that the "Clean City Program" is both analytical and purposive and that solutions proposed are within the framework of government initiatives and legally appropriate.

Citizens co-operation is vital to reduce, reuse and recycling of waste and in keeping garbage off the streets, by keeping biodegradable "wet" kitchen and food wastes unmixed and separate from recyclable "dry" wastes and other hazardous wastes. Their participation in primary collection of waste, using community bins for storage of waste generated in multistoried buildings, societies, commercial complexes and slums is also essential. If the reasons for doing so are explained, public participation is bound to improve.

18.4 MEASURES TO BE TAKEN TO BRING ABOUT A CHANGE IN PUBLIC BEHAVIOUR

A series of measures can be taken to bring about a change in public behaviour through public awareness programs, which could be as under:

18.4.1 Promote "Reduce, Re-use and Re-cycle (R-R-R)" of Waste

18.4.1.1 Reduce

Everyone is concerned with the growing problems of waste disposal in urban areas with the scarce availability of land for processing and disposal of waste and environmental remediation measures becoming ever more expensive. It is therefore necessary to not only think about effective ways and means to process and dispose of the waste that we generate each day, it is also essential to seriously consider how to avoid or reduce the generation of waste in the first place and to consider ways to re-use and recycle the waste, so that the least quantity of waste needs to be processed and disposed of.

While the quantity of food waste generated per capita has remained almost static, the quantity of packaging waste material and non-bio-degradable waste is going up alarmingly every year. This increases the burden on local bodies to deal with the problem of non-biodegradable and non-recyclable components of waste landing up at processing and disposal sites.

The following measures are therefore proposed to be taken to Reduce, Re-use and Recycling of waste by all concerned:

- All manufacturers producing a variety of domestic and non-domestic products, food as well as non-food should be persuaded to seriously endeavour to use re-usable packaging materials so that after the delivery of goods, the packaging materials could be collected back and used over and over again. They could also consider minimizing or avoiding use of unnecessary packaging materials by innovative methods.
- Incentives and product discount should be given to consumers for the return of packaging or bottling materials in good condition, to the waste producers or retailers to promote re-use.
- The cost of packed articles and article without the packaging material could be kept different with a choice to the consumers to take the article without the packaging material at low cost.

18.4.1.2 Re-use

One person's waste can be useful material for others. Efforts should therefore be made to encourage collection of such re-usable material through waste collectors, waste producers, NGOs and private sector instead of allowing reusable waste to land up on the disposal sites. Bottles, cans, tins, drums and cartons can be reused.

18.4.1.3 Re-Cycling

In the era of excessive packaging materials being used, a lot of recyclable waste material is generated. All-out efforts are necessary to retrieve recyclable material from the households, shops and establishments and fed to the recycling industries through intermediaries such as waste purchasers, waste collectors/NGOs, etc.

18.4.2 Promote Public Participation in SWM Systems Adopted

The first and foremost thing that the citizens need to be told and made to understand is that no waste shall be thrown on the streets, drains, water bodies, open spaces, etc. and that they should form habit of:

- Storage of wet food/bio-degradable waste and dry recyclable waste separately at source

- Participation in primary collection of wastes
- Handing over of recyclable waste materials to rag pickers/waste collectors
- Use of community bins wherever directed/provided.
- Use of litter-bins on roads and public places

18.4.3 Provide Information Hot-line

The key to success of any public-education, awareness and motivation program is to provide as many ways as possible for the public to interact, as promptly and conveniently as possible, with policy-makers, to seek clarification of doubts, share ideas or give suggestions which are constructively followed up. A telephone hot line or Post Box number for written communications could be one of the ways to have inputs from members of the public. The phone must be attended during working hours by polite, responsive and dynamic persons who are well informed, interested in the subject and available at all stated times.

18.4.4 Public Education

The communication material developed should be utilised in public awareness programmes through variety of approaches as under.

18.4.4.1 Group Education

This may be done through :

a. Group Meetings in the community
b. Workshops
c. Exhibitions
d. Lecture series
e. Panel Discussions, etc.

18.4.4.2 Mass Education

This is very essential to cover the entire population as it is not possible to reach all the people through group education programs.

Mass Education programs can be planned using following methods of communication.

(i) Use of Print Media:

Advertisements may be given in a planned manner to educate the masses and local newspapers can also be requested to insert the given messages on SWM at regular intervals. They should also be encouraged to start a regular Suggestion Box from where good ideas can be picked up by the local body.

Newspapers maybe specially encouraged to give coverage to successful initiatives that have overcome SWM problems.

ULBs can also use newspaper delivery services by inserting handbills for readers in a particular locality to announce the start of campaign from time to time and to adhere to the systems introduced.

(ii) Use of TV / Cable TV / Radio/Web Site:

This is the very powerful medium and can be used through local programs to inform the citizens of new waste collection arrangements made by the local body as and when they become operational and advise them to participate effectively in the prescribed manner. Contact numbers of the concerned officials for problem solving or reporting of SWM grievances may also be publicized. This media may be used to publicize successful efforts in some localities to motivate other citizens to perform likewise and get similar recognition of their effort.

(iii) Use of Cinema Halls:

Slides in cinema theaters can be displayed to inform and motivate the public.

(iv) Street Plays, Puppet Shows, etc.:

Street plays and puppet shows play a significant role in bringing awareness among the people. This method of communication will work well in low-income population; more particularly in slums. Well designed street plays /puppet shows can convey the messages effectively as such programs are well attended in slums.

(v) Posters:

Attractive posters with good photographs and messages with a very few words, readable from a distance, should be prepared and displayed in various parts of the city where awareness campaign is being taken up.

(vi) Pamphlets:

Pamphlets, hand bills can be printed giving instructions in very simple and understandable language showing photographs in action and circulated in the community requesting public participation.

(vii) Use of Hoarding:

Special hoarding may be put at strategic locations in the city carrying messages seeking public participation. Alternatively, all Municipal-licensed hoarding should have a space reserved at the bottom for civic messages. Such messages should be developed and painted by professional agencies. These hoarding should also carry the contact numbers etc.

(viii) Use of Public Transport System:

Brief messages can be painted on the rear of public buses or inside the bus panels. Public and private firms having their own bus fleets may be invited to support such efforts.

(ix) Use of School Children:

Children are powerful communicators. Parents who do not listen to the advice of others often take their children seriously. Children are idealistic and would like to change their world for better. The ULB should hold regular meetings with principals, teachers and students to explain the need for change, and the usefulness to society of new ways to manage waste. The message can be reinforced by holding essay, debate or drawing and painting competitions on the subject and publicizing the winning contestants. Social clubs can be encouraged to sponsor such events to keep the topic alive. The leading schools could be persuaded to work as a role model for other schools in taking up awareness campaigns in the city through their students, which should be highly publicized and other schools could be persuaded to follow suite.

(x) Primary School Curriculum to cover the subject:

It is an established fact that people form habit at a very young age and habits are hard to change. It is, therefore, necessary to educate young children when they are in primary school to form good habits for managing waste. School curriculum should cover this aspect in the subject of moral science or social studies. This will go a long way in developing enlightened community and least efforts would be required to discipline the people in managing the waste.

(xi) Involvement of National Cadet Corps (NCC), National Social Service (NSS) and Scouts:

In the schools and colleges the students are participating in NCC, NSS and scout activities. These students could also be sensitized on the public participatory aspect in solid waste management and as part of their activities they can be involved in the awareness campaign to bring about a change in public behaviour.

(xii) Involvement of Religious Leaders:

Religious leaders play a significant role in bringing about a change in the mind set of the people. If they advise their devotees/disciples to keep their surroundings clean by not littering anywhere and by managing their waste as advised by the urban local body it will go a long way in improving the situation in the urban areas.

(xiii) Involvement of Medical Practitioners:

Medical practitioners are held in high esteem by the citizens. A word from them to the patients or the community to practice appropriate systems of waste management at home, offices, shops and establishments would help substantially in bringing compliance of the directions of the urban local body to keep the city clean.

(xiv) Involvement of Mahila Mandals/Women Associations:

Women are generally found more concerned in maintenance of health and hygiene and they are involved in domestic waste management on day to day basis. The awareness among the women could be raised through Mahila Mandals/Women Associations who could be given talking points and necessary literatures in a very simple understandable language / graphics for creating awareness among women.

(xv) Resident Associations:

Most citizens want a nearby facility to dispose of their waste, but nobody wants a dustbin at their doorstep. Both needs can be met by the house-to-house collection system through handcarts or tricycles. Neighbourhoods can be rewarded for good response to doorstep collection of segregated waste. Groups that undertake to manage the cleaning of their own area can be rewarded by ULBs through grants/subsidies.

(xvi) Voluntary Organizations/NGO involvement:

Many NGOs are committed to improve SWM practices in urban areas to protect the environment and have been very active in this field. They have also developed good mass-communication skills and education programs for the public. Such NGOs may be persuaded to actively support the new strategies adopted by the local body and associate in public awareness campaigns. Those who wish to conduct programs for sections of the public on the new SWM strategies may be encouraged to do so and given necessary support.

18.5 ENFORCEMENT

All said and done, all human beings are not the same. There are people who understand easily as soon as they are told to behave, there are also people who are hard to understand and there is a special category of people who do not want to understand. While all efforts should be made to educate the people to effectively participate in the management of waste, they also need to be told that they can be punished if they fail to discharge their civic duties. The provision of penalties may be made known to the people and details of those punished should be publicized widely to deter others.

To begin with, the enforcement should begin at the public places, market places, etc. and gradually extended to cover residential areas. Discipline should be brought about in the public offices first so that correct examples be set before the people.

CHAPTER 19

INSTITUTIONAL ASPECTS & CAPACITY BUILDING

19.1. INTRODUCTION

The subject of solid waste management (SWM) has remained neglected for the past several decades with the result the level of service is highly inadequate and inefficient. For improving the solid waste management services it is essential to adopt modern methods of waste management having a proper choice of technology which can work in the given area successfully. Simultaneously, measures must be taken for institutional strengthening and internal capacity building, so that the efforts made can be sustained over a period of time and the system put in place can be well managed. Institutional strengthening can be done by adequately decentralizing the administration, delegating adequate powers at the decentralized level inducting professionals into the administration and providing adequate training to the existing staff. It is also necessary to fix work norms for the work force as well as for supervisory staff and the output expected from the vehicles and machinery utilized. Non-Governmental Organisations/private sector participation also needs to be encouraged to make the service competitive and efficient. It is therefore, necessary that the local body takes adequate measures for institutional strengthening through induction of professionals, decentralization of administration, delegation of powers, human resources development, and private sector and non participation. **This may be done as under:**

19.2. DECENTRALIZATION OF ADMINISTRATION

In large cities the SWM services can be performed effectively only if its administration is adequately decentralised. Decentralisation can be at least 3 tiered -one at the Ward level, second at the Zone level and third at the city level. The SWM functions would get focussed attention if all functions of the city administration are decentralised at Ward/Zone/Division levels and senior officers are placed in-charge of each Zone/Division functioning independently with adequate delegated powers.

The SWM functions may be decentralised as under:

19.2.1 Ward Level Administration

The ward level administration should be fully responsible for ensuring storage of segregated waste at source, primary collection of waste, street sweeping and taking the waste to waste storage depots, clearing debris and cleaning surface drains and public spaces. The cleaning of each street, lane, by-lane, markets and public space should be regularly supervised by the ward-level supervisors. The presence of all SWM officers in the field during morning hours is most essential. A grievance redressal system of the Ward should be put in place in each ward.

Involvement of Ward Committees:-

The 74^{th} Constitutional Amendment envisages formation of Ward Committees in each city above 3 lac population. These Ward Committees, as and when formed, may be very profitably involved in improving SWM services at the Ward level. These Committees could be motivated to help in the following areas:-

- Creating public awareness at the Ward level;
- Formation of Residents Association/ Neighbourhood Committees to ensure public participation in source segregation of recyclable waste and deposition of domestic waste in the handcarts on time during primary collection;
- Involving school children to be watch dogs in preventing littering of streets by the people;
- Interfacing with the people and officials and help in redressal of public grievances on SWM at the ward level;
- Supporting the effort of cost recovery for the services rendered;
- Encouraging NGO participation.

19.2.2 Zonal Administration

Administrative Zones should be made for a group of wards. Each Zone can cover a population of about 5 lac people.

The Zonal administration should effectively supervise and support the work of the Ward administration and also provide Zonal level support such as construction and upkeep of flooring under the communal waste storage sites, transportation of waste from the communal storage sites to the transfer station, processing plant and disposal sites. If the Zones are not allotted adequate vehicles for the transportation of waste due to paucity of vehicles, the transportation of waste may be coordinated centrally for optimum utilization of the fleet of vehicles in 2 or 3 shifts.

19.2.3 City Level Administration

The city level administration should supervise and support the Zonal administration and in cases where the fleet of vehicles is not decentralized at the zonal level, the central SWM Department should look after the transportation of waste from the waste storage sites on a daily basis. The Central SWM Department should be responsible for procurement and upkeep of vehicles, construction of transfer stations, setting up and maintenance of processing plants, incineration plants as well as for managing the disposal sites in an environmentally acceptable manner.

The central SWM department should also be responsible for the procurement of land for processing and disposal of waste. As a Head Office it should take policy decisions and co-ordinate the activities of all the zones and the wards and be answerable to the Chief Executive and elected body for the efficient functioning of the department. It should look after the recruitment of manpower, human resources development, training etc.

19.3. DELEGATION OF POWERS

Authority and responsibility should go hand in hand. For fixing accountability there should be adequate delegation of fiscal and disciplinary powers to the officers and the supervisory staff responsible for managing solid waste and carrying out all day-to-day functions smoothly.

The Head of the SWM department should also have the power to punish subordinates including supervisory staff. Adequate in-built checks may be introduced to ensure that the delegated powers are not misused.

19.4. ORGANIZATIONAL SET UP/PUBLIC HEALTH ENGINEERS

The subject of solid waste management, so far being handled by Health Officers (who are medical doctors) in most cities, now needs to be handled by environmental engineers or public health engineers with the support of mechanical/automobile engineers to handle the workshop facilities. Qualified engineers should, therefore, be regularly inducted in cities above l00,000 population. The following yardstick could be followed for induction of professionals in the solid waste management services:

19.4.1 Towns Below 1,00,000 Population

One qualified sanitation diploma holder as

Sanitary officer (S.O.) if the population is more than 50000.

One qualified Sanitary Inspector (S.I.) @ 50000 population.

One qualified Sanitary Sub-Inspector (S.S.I) @ 25000 population.

One Sanitary Supervisor (S.S.) @ 12,500 population.

19.4.2 Cities Between l and 2 lacs Population

- Public Health/Environmental Engineer /or Civil Engineer having training in environmental/public health engineering in the grade of Assistant Engineer to be in charge of SWM department.
- Qualified Sanitation Diploma holder/Sanitation Officer @ one S.O. per l lac population or part thereof to look-after the collection, transportation, processing and disposal of waste or @ 1 per 2 Sanitary inspectors, whichever is less.
- Qualified Sanitation Diploma holder Sanitary Inspector(S.I.) @ one S.I. per 50,000 population or part thereof or @ 1 per 80 sweepers, whichever is less.
- Qualified sanitation diploma holder Sanitary Sub-inspector (S.S.I.) @ one S.S.I. per 25,000 population or part thereof or @ l per 40 sweepers, whichever is less.
- Sanitary Supervisors (a person who can read, write and report) @ one S. S. per 12,500 population or part thereof, or 1 per 20 sweepers, whichever is less.

19.4.3 Cities Having Population Between 2 and 5 lacs

- Public Health/Environmental Engineer/or Civil Engineer having training in environmental or public health engineering in the Grade of Assistant Executive Engineer to be in charge of SWM department.
- Public Health/Environmental Engineer in the grade of Assistant Engineer to look after the transportation, processing and disposal of waste.
- Sanitary Officers @ one S.O. per l lac population for supervising the storage, street sweeping and primary collection of waste.

- Sanitary Inspectors, Sanitary Sub-inspectors, Sanitary Supervisors should be as per the yardstick indicated in 19.4.2above.

19.4.4 Cities Having Population Between 5 and 20 lacs

- Public Health/Environmental Engineer/or Civil Engineer having training in environmental or public health engineering of the level of Executive Engineer to be in-charge of the SWM department.
- Public Health/Environmental Engineers/or Civil Engineer having training in environmental or public health engineering of the level of Assistant Executive Engineer per 5 lacs population.
- Public Health/Environmental Engineers/or Civil Engineer having training in environmental or public health engineering of the level of Assistant Engineer per 2.5 lacs population.
- Sanitary Officers, Sanitary Inspectors, Sanitary Sub-inspectors and Sanitary Supervisors as per yardstick indicated in 19.4.2 above.

19.4.5 Cities Having Population Between 20 and 50 lacs

- Public Health Engineer/Environmental Engineer/or Civil Engineer having training in environmental or public health engineering of the level of Superintending Engineer to be the Head of SWM Department.
- Public Health/Environmental Engineers/or Civil Engineer having training in environmental or public health engineering of the level of Executive Engineer @ one Ex. Eng. per 20 lacs population or part thereof.
- Rest of the supervisors and staff as per the yardstick already indicated in 19.4.2 to 19.4.4 above.

19.4.6 Cities Above 50 lacs Population

- Public Health Engineer/Environmental Engineer/or Civil Engineer having training in environmental or public health engineering of the level of Chief Engineer to be in charge of the SWM department.
- Superintending Engineer per 40 lac population or part thereof. Rest of the officers, supervisor's etc. as per yardsticks already indicated in 19.4.2 to 19.4.5 above.

Note: In cities where health officers are looking after SWM or part thereof, in addition to their principal function of taking preventive health measures, they may be gradually made free from this responsibility and replaced by environmental or public health engineers.

Typical organogram for a large city is suggested as at Annexure – 19.1

19.5 HUMAN RESOURCES DEVELOPMENT

Human resources development is very essential for internal capacity building for any organisation. Training, motivation, incentives for outstanding service and disincentives for those who fail to perform are essential for human resources development.

Concerted efforts should be made by the local body to inculcate among its officers and staff a sense of pride in the work they do and to motivate them to perform and give their optimum output to improve the level of services of the city and the image of the local body.

19.5.1 Training

Solid Waste Management has been a neglected subject for the past several decades. Systems have, therefore, not developed to improve the service. Knowledge of new technology and methods coupled with training at all levels is necessary. No specialized courses have so far been designed to meet need of different levels of staff. Short and medium term courses should, therefore, be designed for the sanitation workers and supervisory staff. Special training and refresher courses may also be conducted as under:-

19.5.1.1 Special Training To Unqualified Staff

Unqualified supervisory staff should be given in service training to qualify for supervising sanitation works. They may be sent out for training to the All India Institute of Local Self Government or such similar institutions which designs special courses for sanitation supervisors.

19.5.1.2 Refresher Courses For All Levels of Staff

Refresher courses should be conducted for the sanitation workers as well as supervisory staff at least once in every 5 years, or they should be sent for training to get an exposure to advance in this field. The course content could be as per Annexure-19.2.

19.5.1.3 Exposure to Municipal Commissioner/ Chief Executives

It is necessary to give an orientation to the Municipal Commissioners/Chief Executives of the local bodies and make them aware of this important aspect of

Urban Management. They may therefore be given exposure to SWM through short training programs.

19.5.1.4 Exposure to Elected Members

Whereas the Municipal Commissioners or the Chief Executives are responsible for day-to-day affairs of the urban local bodies, the elected members are the policy makers and their sanctions are essential for any major investments or improvements in SWM services. It is, therefore, necessary that the members of the elected wing such as the Mayors/Presidents of the Corporations/Municipalities and other important office bearers of the local bodies are given appropriate orientation towards the need of modernization of solid waste management practices in the urban areas and the importance of the same in terms of health and sanitation in the cities/towns. If these members are given an appropriate exposure, they would automatically support adequate financing for solid waste management services and strengthen the hands of chief executives in the implementation of modern methods of waste management and they would also help in getting public support through their network of field workers.

19.5.1.5 Design SWM Courses

SWM courses may be designed and regularly updated for Engineering, Medical and applied science disciplines. Academic institutions at the national and state levels should be involved in this exercise by the concerned departments of Central and State Governments respectively. The syllabus of the engineering colleges, medical studies as well as sanitary inspectors' diploma courses should lay adequate emphasis on solid waste management.

19.5.2 Promotional Opportunities

Adequate promotional opportunities should be available in the decentralised SWM hierarchy to maintain the interest of the supervisory staff to remain in the department.

19.6. WORK NORMS

Norms of Work for Street Sweepers

The sweepers may be given "Pin point" individual work assignments according to the density of the area to be swept. The yardsticks given earlier could be adopted as under:-

WORK NORMS:

19.6.1 Norms of Work for Street Sweepers

- High density area & Markets (Population above 50000 per sq.km.) = 250 to 350 Running Metre (RMT)
- Medium density area (Population from 10000 to 50000 per sq.km.) = 400 to 600 RMT
- Low Density area (Population less than 10000 per sq.km.) = 650 to 750 RMT

The sweepers may be directed to sweep the roads and footpaths in the area allotted to them as well as to collect the domestic, trade and institutional wastes in their handcart from the households, shops and establishments situated on the road/street allotted to them.

The above sweeping norms are for cleaning the streets in the first 4 hours of the working day. In the remaining hours of the day, if there is a continuous 7/8 hours duty, or in the evening session, if there is broken duty, the sweepers should be assigned pin point work for cleaning the streets in slums and unauthorized settlements to ensure hygienic conditions in the city and prevent the problems of health and sanitation arising in such areas.

The roads, which have a central verge or divider, should be considered as two roads. In such cases, the length of the road allotted for sweeping should be reduced to half or alternatively separate sweepers may be engaged for sweeping two sides of the road.

The yardstick for cleaning open spaces should be prescribed looking to the local situation. However, 30,000 sq.ft. of open space can be given to a sweeper for cleaning per day.

Similarly work norms can be prescribed for variety of vehicles used depending upon the distance to be traveled and the places to be covered. These norms may be prescribed after conducting time and motion study.

Normally one vehicle carrying containers could make 7 - 8 trips to the processing and disposal site if the distance is less than 5 kms. If the distance is between 5 and 10 Kms, 5 trips could be made. In cases where the distance is beyond 10 kms, the no. of trips could reduce to 3 or 4 per shift depending on the distance to be travelled.

Norms of work for supervisors may be prescribed and monitored by the local body for inspection of sweeping done, clearance of waste storage depots, transportation of waste carried out, etc. Inspection of processing and disposal sites by various levels of supervisors may also be prescribed to ensure adequate output of all the supervisory staff.

The first level supervisors could be asked to inspect the work of all the sweepers at least once in two days. The sanitary sub-inspectors should inspect all the beats twice a week and the sanitary inspector at least once a week. All temporary waste storage depots must also be inspected by the same level of supervisors with the same frequency.

All Supervisory Officers right from Sanitary Sub Inspector to Health Officer/Chief Engineer in-charge of SWM department must remain on the field for 4 hours in the morning between the time of street sweeping and lunch break. The timings for the lower and middle level supervisor should extend beyond the duty hours of the sanitation workers in the afternoon/evening to verify whether work has been done properly. This supervision will have a direct impact on the quality of service.

For capacity building of the department, senior officials should be frequently exposed to developments taking place in various parts of the State/ country by sending them out on city visits and for attending seminars, workshops and training courses. They should also be involved in all decision making processes.

19.7 THE ENTIRE ADMINISTRATION OF SWM DEPARTMENT TO BE UNDER ONE UMBRELLA

With a view to avoiding the problems of lack of coordination and passing of the responsibility on others, it is necessary to have one person exclusively in charge of SWM in the city. The overall control in relation to collection, transportation, processing and disposal of all waste, including workshop facilities, should lie with him. He should also be responsible for the cleaning of open drains under 24 inches depth, collection of silt, construction waste and debris and vehicle deployment and maintenance. This work should not be left to the Engineering Department, which should however continue to be responsible for the removal and transportation of silt from the underground drains, storm water drains or surface drains exceeding 24 inches depth, and the left over waste material from their Engineering and major road works.

19.8 INTER-DEPARTMENTAL CO-ORDINATION

Since the SWM department depends greatly upon the support of various departments of the local body, more particularly the Engineering department, the Chief Executive of the local body should hold regular monthly co-ordination meetings to sort out problems faced by the SWM department such as expeditious repairs of roads, drains, water-supply pipe-lines etc. which cause hindrance to street and city cleaning. The reinstatement of roads dug up by utility services should also be given priority.

The procurement procedures for the SWM equipment also need to be expedited and simplified in such meetings. A Rate-contract system should replace time consuming tendering procedures.

There should be an Apex Committee comprised of representatives of various utility services, headed by the Chief Executive of the local body, to co-ordinate the laying of underground services in the city by various utilities and the reinstatement of the roads as soon as the underground services are laid. The Apex Committee should ensure that repeated digging of road is avoided for laying of services by various utilities at time. The works to be carried out by various utilities on a particular road should be coordinated to prevent frequent digging of roads. Laying and maintaining of services in slums, provision of public health engineering services and water supply for public toilets and road construction in the slums to improve overall health and sanitation in the city may also be regularly reviewed in the co-ordination committee meetings.

19.9. ENCOURAGEMENT TO NGOS AND WASTE COLLECTOR CO-OPERATIVES

NGOs may fully involved in creating public awareness and encouraging public participation in SWM planning and practice.

The local body may also encourage NGOs or co-operative of rag pickers to enter this field and organise rag pickers in doorstep collection of waste and provide them an opportunity to improve their working conditions and income. The local body can give incentives to NGOs in their effort of organising rag pickers in primary collection of recyclable and/or organic waste, and provide financial and logistic support to the extent possible. (Refer Chapter 18)

19.10 VOLUNTARY ORGANIZATION/ NGO/ PRIVATE SECTOR PARTICIPATION

SWM services are highly labour intensive on account of increased wage structure of the Government and municipal employees this service is becoming more and more expensive. Besides, the efficiency of the labour force employed in the urban local bodies is far from satisfactory. High wage structure and inefficiency of the work force results into steep rise in the cost of service and yet the people at large are not satisfied with the level of service being provided by the urban local bodies. Efforts to increase the efficiency by Human Resource Development and institutional strengthening will, to some extent improve the performance but that may not be enough. It is, therefore, necessary that the local bodies seriously consider Voluntary Organisations/NGO/private sector participation in solid waste management.

Private sector participation or public private partnerships may be considered by urban local bodies keeping in mind the provisions of the Contract Labour (Regulation and Abolition) Act 1970 of the Government of India, the details of which are described in chapter 20. This will check growth in the establishment costs, bring in economy in expenditure and introduce an element of healthy competition between the private sector and the public sector in solid waste management services. There should be a right mix of private sector and public sector participation to ensure that there is no exploitation of labour as well as of the management.

19.11 INCENTIVES TO THE PRIVATE SECTOR

Solid waste management, processing and disposal is an area where the private sector has still not shown much interest. The private sector has, therefore, to be given some incentives by way of long term contract, assured supply of garbage at the plant site, lease of land at nominal rates for entering this field. This matter is explained in detail in chapter 20 of the Manual.

19.12 LEVY OF ADMINISTRATIVE CHARGES

With a view to ensure adherence to the instructions given by the civic body to the citizens and making them aware of their civic responsibility of not littering the street and throwing the solid waste anywhere on the streets or open spaces, it is recommended that provision should be made in the relevant by-laws, rules etc to recover Additional Cleaning Charges from the citizens who dispose of waste on the street or in open public places necessitating the cleaning of the road again by the local body. The power to levy such charges should be delegated to the supervisors of the level of Sanitary Inspectors and above. The amount of additional cleaning charges to be levied should be specified for different categories of offenders and should be kept higher for repeat offences. Refer Chapter 24).

19.13 MOBILE SANITATION COURTS

It is the tendency of the public to take their civic responsibilities lightly. It is therefore necessary that while on one hand people are motivated to participate effectively in keeping the cities clean, there should be a fear of punishment if they fail to discharge their civic obligations. Provision of Mobile Sanitation Courts is therefore recommended in one million plus cities to punish on the spot the offenders violating the sanitation laws and civic instructions for keeping the cities clean. The mobile court's jurisdiction should be for the entire city covering areas managed by railway, cantonment, airport etc. within the city boundaries. The working arrangements could be made with various authorities operating in the city to make the mobile sanitation court effective in the city. The mobile sanitation court would be able to recover its full cost from the fines that may be imposed by the court. There is, therefore, no likelihood of any financial burden on the local body, railways, cantonments, etc.

19.14 DOCUMENTATION OF BEST PRACTICES

It is seen that good practices are seldom documented. This may be arranged from time to time by the Ministry/Department of Urban Development of Central/State Governments in order to have development through spread effect.

19.15 REDRESSEL OF PUBLIC GRIEVANCES

The local body should draw up a citizen's charter clearly stating what level of service it proposes to provide to the citizens and how soon citizens can expect their grievances to be attended. Sanitation being very vital for health and environment, an efficient machinery should be organized by the local body to receive public complaints and attend to them expeditiously. Formats may be prescribed for receiving such complaints, replying to the applicants as soon as the complaints has been redressed and for monitoring the pending complaints. (Refer Chapter 24 on Legal Aspects).

ANNEXURE – 19.1

TYPICAL ORGANISATION CHART FOR A CITY OF 30 LACS POPULATION

Explanation to the organizational chart.

The Central Workshop shall provide the required number of vehicles to the Executive Engineer in charge of transportation who shall manage the fleet of vehicles through Assistant Executive Engineer in charge of transportation. The Assistant Executive Engineer shall be assisted by three Assistant Engineers at the rate of one assistant engineer per shift. In the cities where no operations are carried out in the third shift, two assistant engineers could be placed on duty in the first shift to manage the transportation effectively.

The Assistant Executive Engineers in charge of collection for every 10 lacs population shall maintain a liaison with Assistant Executive Engineer in charge of transportation who shall have one assistant engineer in each shift to ensure that vehicles reach the respective divisions on time and in adequate numbers.

The Assistant Executive Engineer processing and disposal shall also have three assistant engineers, one for each shift to look after both processing and disposal sites to be supported by lower level of supervisors for each site. In the cities where no night operations are conducted and major load is taken in the first or second shift, the night shift assistant engineer could be utilized in the first or second shift.

The Assistant Engineers in charge of collection shall look after the collection in their respective areas with the assistance of sanitation officers, sanitary inspectors, etc., and maintain all the waste storage depots constructed in their areas in a perfect condition and ensure that all the tools given to sweepers for primary collection are kept in order and properly repaired and maintained.

STAFFING AND QUALIFICATION NORMS FOR DIFFERENT SIZES OF CITIES

City Population	1 Lac	2 Lac	5 Lac	20 Lac	40 Lac	Over 40 Lac
SWM Supervisory cadre						
C.E. = Chief Engineer to be a Public Health/Environmental Engineer in Charge of city of SWM Deptt. in cities about 40 lakh	-	-	-	-	-	1
S.E.= Superintending Engineer to be a Public Health/Environmental Engineer of cities above 20 lac @ (1 per 40 lakh pop or part)	-	-	-	-	1	1+
E.E.= Executive Engineer to be a Public Health/Environmental Engineer for cities above 5 lac population @ (1 per 20 lac pop or part)	-	-	-	1	2	2+
A.E.E = Asstt. Executive Engineer to be a Public Health/Environmental Engineer in the cities above 2 lac population @ (1 per 5 lac pop or part)	-	-	1	4	8	8+
A.E.= Asstt. Engineer to be a Public Health/Environmental Engineer in cities above 1 lac population @ (1 per 2 lac pop or part)	-	1	2	8	16	16+
S.O.= Sanitary Officer to have Sanitary Diploma (1 per 1 lac pop)	1	2	5	20	40	40+
S.I.= Sanitary Inspector to have Sanitary Diploma (1 per 50,000 pop or 1 per 80 sweepers* whichever is less)(1 per 2 SSI)	2	4	10	40	80	80+
S.S.I = Sanitary Sub-Inspector, a diploma holder in Sanitation (1 for 25,000 pop or 1 per 40 Sweepers, whichever is less(?? Or per 2 SS ??)	4	8	20	60	80	160+
Mukadam or Jamadar or Daffadar or Maistry who is literate, (1 for 12,500 pop or 1 per 20 sweepers, whichever is less)	8	16	40	160	320	320+
Sweepers as per norms(para 3.8)						

ANNEXURE-19.2

Brief course content for training to various levels of staff/Officers

A. **Training to sanitation workers**.

1. Importance of sanitation in urban areas.
2. Present scenario of solid waste management system in the urban areas, deficiency in the system, etc.
3. Impact of inefficient SWM services on health and environment
4. Impact of inefficient SWM services on the health of sanitation workers.
5. Inefficiency of tools and equipments used and loss of manpower productivity.
6. Need for modernization of solid waste management practices.
7. Options available for improving the services.
8. Advantages of using improved tools and equipments for primary collection of waste and street sweeping.
9. Need for synchronization of storage of waste at source, primary collection of waste and waste storage depots.
10. Proper upkeep of tools and equipments and waste storage depots.

B. Training to Sanitation Supervisors of various levels.

1 to 10 as per A above.

11. Need for synchronization of transportation of waste with waste storage depot.
12. Transportation of waste on day to day basis.
13. Waste processing and disposal options, advantages and disadvantages of various technologies.
14. Sanitary land filling.

15. Public and NGO participation in waste management.
16. Building public awareness.
17. Enforcement.

C. Training for the officers looking after SWM Department.

1 to 17 as per A & B above.

18. SWM practices prevalent in other parts of the country and in the developed countries
19. Institutional strengthening, internal capacity building and human resources development.
20. Private sector participation in SWM
21. Management information system.
22. Financial aspects.
23. Health aspects.
24. Legal aspects.

CHAPTER 20

PROSPECTS OF PRIVATE SECTOR PARTICIPATION

20.1. INTRODUCTION

Solid waste management (SWM) is one of the obligatory functions of the urban local bodies in the country. The local bodies are, therefore, required to provide adequate services for the collection, transportation and disposal of waste.

SWM service is highly labour intensive and on account of increased wage structure of the Government and municipal employees, this service is becoming more and more expensive. Besides, the efficiency of the labour force employed in the urban local bodies is far from satisfactory. High wage structure and inefficiency of the work force results into steep rise in the cost of service and yet the people at large are not satisfied with the level of service being provided by the urban local bodies. It is, therefore, necessary that the local bodies may seriously consider private sector participation in solid waste management.

20.2. PRESENT SCENARIO

Private sector participation is relatively a new concept in India for handling solid waste. Private sector has so far not been attracted in this important area of municipal service. However, private sector participation is being attempted by a few local bodies in the country for the past few years, which has remained restricted in the area of awarding contract for transportation of waste from waste storage depots/dust bins. In some cities, contracts are also given to clean streets, provide bullock carts with labour for primary collection of waste, provide only vehicles with or without drivers for transportation of waste, set up treatment facilities for the final disposal of waste with or without financial participation of the urban local body.

20.3. MEASURES TO BE TAKEN BY LOCAL BODIES

Private sector participation or public private partnerships may be encouraged/attempted by the urban local bodies keeping in mind the provisions of Contract Labour (Regulation and Abolition) Act 1970 of Government of India where contracting out of the services already being provided by the urban local bodies can be prohibited/restricted by the State Government and some states have accordingly prohibited contracting out of such services **(See Box)**. Therefore, while considering any measure of privatization one should keep in mind the provisions of above law and the restrictions imposed by the respective state governments in this matter. Urban local bodies may move the respective state governments to get exemption from engaging contractors for providing SWM services or even privatizing those services. Private sector participation should generally be considered in those areas where Municipal Corporations or municipalities are not providing the service. This will check the growth in the establishment cost, bring economy in expenditure and introduce the element of healthy competition between the private sector and the public sector in solid waste management services. There should be right mix of private sector and public sector participation to ensure that there is no exploitation of labour as well as of the management.

RELEVANCE OF CONTRACT LABOUR (REGULATION & ABOLITION) ACT, 1970

(a) Under Section 10(1) of the said Act, the competent authority to abolish/prohibit a particular activity or to exempt Urban Local Body from the purview of the said Act is the concerned State Government.

(b) Unless and until a particular activity under the said Act is abolished/prohibited by the "Appropriate Government", the contract labour can be employed.

(c) If a particular activity is of perennial nature, "Appropriate Government" can abolish such activity under Section 10(1) of the Act, in consultation with the Advisory Board and direct the local body to carry out such a function with its own labour/work-force and not through contract labour.

(d) If a State Government which is an "Appropriate Government" for a local body has not prohibited activities such as street sweeping, garbage collection, etc., contract labour can be employed by a local body to carry out the same until the State Government abolish such activity. Further, as per the direction of Supreme Court in Air India case, once an activity is abolished, the existing contract workers doing such jobs will automatically become regular employees of the establishment.

(e) If a private agency takes up the job of collection of household waste and transport the same either to the municipal dust bin or up to the designated dumping sites as per an agreement reached with individual household or by the residential associations, the said activities cannot be taken as done at the instance of the Urban Body and such Urban Local Body can not be taken as the principal employer.

(f) The existing contract labour Act is being considered for review by the Government and it will take some time to finalise the same.

Source: Ministry of Labour, Govt. of India.

20.4. AREA WHERE PRIVATISATION CAN BE ATTEMPTED

Private sector participation may be considered in newly developed areas, under served areas and particularly in the areas where local bodies have not been providing service through their own labour force. Some of the examples of the areas where private sector participation can be considered are as under:

Door to door collection of domestic waste, door to door collection of commercial waste, door to door collection of hospital waste, hotel waste, construction waste, market waste, setting up and operation and maintenance of waste disposal facility, setting up and operation and maintenance of waste treatment plants, supplying vehicles on rent, supplying vehicles on lease, repairs and maintenance of vehicles at a private garage, transportation of waste on contractual basis, etc.

The contracts should carry a provision of penalty for failure to perform the contractual obligation.

The local body while giving a contract to a private sector, voluntary organization/Non-Governmental Organisation (NGO) should make an enabling provision in the contract to inspect the performance of the private contractor from time to time and as a matter of rule should inspect the performance of the private contractors to maintain the quality of services, prevent corrupt practices and take remedial measures,. The formats should be prescribed for such inspections and results of inspections should be reported to the higher authorities at regular intervals.

20.5. METHOD OF PRIVATE SECTOR INVOLVEMENT IN DOORSTEP COLLECTION OF VARIETY OF WASTES

Tenders could be invited by the local body for private sector participation in doorstep collection of waste. The private entrepreneur getting contract may select his own team of workers, give them containerised tricycles or handcarts or other vehicles, tools and equipments necessary for door step collection of waste. He may allot 200 to 300 houses, or adequate no. of shops, hotels, restaurants, etc., depending on the distances to be traveled and garbage/waste to be collected and arrange for day to day collection of waste from such premises. He may collect the charges as per the rates fixed by the local body per unit per month for door step collection of waste. He should have his own supervisors to ensure that door to door collection service is given efficiently and local body may just over see by occasional inspection to see that services are adequately being provided in the given areas through private sector and no over charging is done. The persons engaged by the private sector for door step collection should be allowed to take away recyclable material and also be allowed to dispose of other waste into the municipal system/municipal bins in the city in the manner as may be prescribed by the local body.

The local body may also encourage NGOs to enter into this field and organise the waste collectors in doorstep collection of waste and provide them an opportunity to earn their living. The local body can give incentive in cash or kind to NGOs in their effort of organising waste collectors in primary collection of recyclable and/or organic waste.

20.6 INCENTIVES TO PRIVATE SECTOR

Solid waste management is one such an area where private sector has still not found much interest. Private sector has, therefore, to be given some incentives by way of long term contracts, assured supply of garbage at site, lease of land at nominal lease rent, etc., for entering this field.

- Contracts may be given for doorstep collection of waste from households, shops and establishments, hotels, hospitals, for a period not less than 3 years so that the contractor may be in a position to invest money for buying equipment. The contractors will have no interest in short-term contract, as investment made may become redundant if the contract is not subsequently renewed.
- Private sector may be offered waste land at a nominal rent for not less than 15 years for setting up treatment plants such as compost plant, bio-methanation plant, energy generation plant, etc. The terms for getting royalties from the private sector can be worked out by local bodies through mutual negotiations.
- If vehicles etc. are to be taken on rent or workshop facilities are to be taken from private sector, the term of contract can be for 3 to 5 years so as to enable the private sector to invest money in the procurement of vehicles and machinery.
- However, private sector participation may be encouraged in such a way that it does not affect the interest of the existing labour, it does not violate the provisions of the above law, does not exploit the private labour and yet reduce the burden of the urban local body of new establishment. This will substantially help in improving the quality of service of the urban local bodies, effect economy in expenditure and would also give a scope to private sector entering in waste management market.
- An arrangement of BOO (Build, Own and Operate), BOOT (Build, Own, Operate and Transfer) or any other arrangement which may be transparent and beneficial to local body may be made keeping in view above observations.
- There may be situations where urban local bodies may not have adequate lands for waste treatment and/or disposal or local bodies find it difficult to manage the same departmentally. In such situations they may consider private sector providing waste treatment and disposal facilities on its own land or on municipal land and local body may pay tipping fees for the treatment and disposal of their garbage by private entrepreneur. However, cost benefit analysis should be carefully carried out by the local body while agreeing to such an agreement.

20.7. SOME EXAMPLES

Bangalore, Jaipur, Rajkot, etc., cities award contracts for transportation of waste from the temporary waste storage depots through contractor's labour and vehicles. Tenders are invited and the lowest bidders are given the annual contracts for transportation of waste. Payments are made on per metric tonne basis, restricting the total tonnage per truck and having a penalty provision for failure to perform or delay in clearance of bins.

- In the city of Surat contracts for night cleaning of important roads are given to keep the major roads clean. Rate per square metre is fixed for making the roads dust free with the help of brushes. The measurements of roads are taken keeping in view the portion of the road width to be cleaned and not the entire road width. Giving contract of cleaning 0.75 metre road width on each side of the road is considered adequate for street cleaning to keep the roads clean and dust free.
- Hyderabad city has introduced a contractual system of street cleaning as well as transportation of waste where the city is divided into operational groups and contract is given keeping in view the quantities of waste generating in that area under normal circumstances. The contractors are paid fixed monthly amount for the area allotted to them.
- City of Mumbai, Bhopal, Bangalore, Thane, Ahmedabad, etc., have entered into a contractual arrangement with private sector for setting up compost plants themselves or through a franchisee where either the private sector or its franchisee invest money and the local body provides assured quantity of garbage at the processing plant without levying any changes. The private sector pays some royalty to local body and undertakes all the responsibility of managing the waste and its conversion into a compost at its own cost. The land is given to the private sector on a nominal lease rent for a long term of 15 - 30 years.
- The State Government of Tamil Nadu has exempted the Chennai Municipal Corporation from the purview of contract labour (Regulation & Abolition) Act 1970 vide its order No. 40 MS No. 99 dated 8th July 1999 allowing the said municipal corporation to engage contract labour for sweeping and scavenging activities, a copy of government order is appended as Annexure 20.1. The private sector participation has been operationalised in one zone of the city since 5th March, 2000.

ANNEXURE 21.2(A)

SALIENT FEATURES OF INCENTIVES GIVEN BY MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES

FUEL/ENERGY RECOVERY FROM URBAN/MUNICIPAL AND INDUSTRIAL WASTE

1.0 DETAILS OF THE SCHEME

The details of the scheme is described in brief as under:

1.1 ELIGIBLE TECHNOLOGY

- Biomethanation	- Gasification/Pyrolysis
- Pelletisation	- Incineration
- Sanitary Landfilling with gas/energy recovery	- Mix of above technologies

1.2 CAPACITY

Projects with following minimum capacities shall qualify for consideration

Waste to energy (Solid fuel)	:	15 TPD
Waste to energy (Gaseous fuel)	:	50m/hr
Waste to energy (Electricity)	:	100 KW
Waste to energy (Combined form)	:	100 Kwe

1.3 ELIGIBLE AGENCIES

Following agencies are eligible as promoter for fuel/energy recovery projects

- Private and Public Sector	- ULBs/Municipal Bodies
- Entrepreneurs/Investors capable of Making promoters equity	- Registered companies/Industries etc. Govt. Department/Undertakings
- Community based organisation/NGOs	-

Scheme is open for operation on **BOO, BOOT, BOT** and **BOLT** mechanism.

1.4 INCENTIVES AVAILABLE FROM MNES

For the purpose of development, Fuel/Energy recovery projects have been divided in the following categories.

Commercial Projects : Schemes based on proven/established technology. Two types of schemes are eligible under this categories of schemes:

a) Power generation projects
b) Waste to fuel projects

Demonstration Projects : Projects/Schemes based on emerging technology

Energy Recovery at STPs : For mounting of energy recovery system on STPs.

1.5 FINANCIAL INCENTIVES

Commercial Schemes	**Demonstration Project**	**Energy Recovery at STPs**
Investment Subsidy: **A) Power Generation Projects :** Equivalent to 50% of equity stake of the promoters in the project limited to Rs.1 Crore/M We. **B) Waste to fuel Projects** : Equivalent to 50% of equity stake of the promoters in the project limited to Rs.50 lakhs/Mwe where wastes are converted to biogas, pellets etc. Investment Subsidy is payable through lead FIs in the instalment linked with the progress. Interest Subsidy : Equivalent to 10% of the loan amount subject to maximum of Rs.1 crore/Mwe. Interest Subsidy is payable through lead Fis. The capitalisation of interest subsidy will be worked out with an annual discount rate of 12%. Interest subsidy is payable through lead FIs in the instalments linked with the progress.	**Investment Subsidy :** Equivalent to 50% of the project cost limited to Rs.3 crore/Mwe. Investment Subsidy is payable through lead Fis in the instalments linked with the progress.	**Investment Subsidy :** Equivalent to 50% of the incremental capital cost of biogas generation equipment for mounting energy recovery system on existing Plant.

SALE OF POWER

Following options are available to promoters of fuel/energy recovery projects for sale of electricity:

- Wheeling, banking of power using SEBs grid for third party sale is permitted.
- Alternatively, SEBs will purchase electricity at a minimum recommended rate.

Note : The guidelines for National Programme for Energy Recovery from Urban/Municipal/Industrial waste may be referred for further details.

BAGASSE BASED CO-GENERATION

2.0 FINANCIAL INCENTIVES

A. Demonstration Scheme :

Co-operative/Public/Joint Sector Sugar Mill

Govt. Grant : Equivalent to 50% of total project cost or up to Rs.2 crores/MW of surplus power whichever is lower.

- Govt. grant will be utilised by the FIs to provide the existing co-operative/public sector sugar mills a capital subsidy of Rs.70 lakhs/MW surplus power, subject to a maximum of Rs.6 crores per project and a long term soft loan of Rs.1.30 crores/MW of surplus power at an interest rate of 9% beside their own loan at commercial terms.
- For new sugar mills of both the categories subsidies will be half of the level mentioned above.
- State Govt. will also have to provide a fresh equity of Rs.25 lakhs/Mwe of surplus power to avail benefit of Central Govt. incentives.
- Independent Power Producers(IPP) will also be eligible for financial incentives. However, in such cases MNES grants will be on par with private sector projects.

B. Interest Subsidy Scheme

1. **Projects generating 4MW or more Surplus power involving change of boiler & turbine**
   Interest Subsidy : Equivalent to Rs.35 lakhs/MW to the promoters payable through Fis in the form of subsidized loan provided loan component of the project is at least 60% of the project cost and project cost of Rs. 4 crores/MW.

2. **Projects using their existing facilities with minor modification for generating 1-4 MW of surplus power**
   Interest Subsidy : Equivalent to Rs.15 lakhs/MW to the promoters payable through FIs in form of subsidized loan provided loan component of the project is at least 60% of the project cost and project cost of Rs.1.5 crores/MW.

SALE OF POWER

Following options are available to promoters of Bagasse based co-generation projects for sale of electricity:

- Wheeling, banking of power using SEBs grid for third party sale is permitted.
- Alternatively, SEBs will purchase electricity at a minimum recommended rate

Note : The guidelines for "National Programme for Bagasse based Co-generation Power projects" may be referred for further details.

ANNEXURE – 21.2(B)

SALIENT FEATURES OF MINISTRY OF AGRICULTURE GUIDELINES FOR RECOVERY OF COMPOST FROM URBAN/MUNICIPAL WASTE

Type of Scheme	Centrally Sponsored
Extent of Grant	1/3rd of Project Cost subject to a maximum of Rs.50 lakhs per project. Grant to be provided for building, plant & machinery only. Consultancy fee not included in grant.
Capacity of Plants to be taken up	50-100 TPD
Nos. of Projects to be taken up	36 Nos.
Total Central Assistance proposed during IXth Plan period	18 crores
Procedure for release of Central grant	Through State Govts.
Availability of land	State Govt./Civic body to make available land Agency managing/running to bear other costs such as staff salary etc.
Operation and Maintenance of Compost Plants	State Govt. has complete flexibility to obtain viable technology from any source. State Govt. may involve Local Bodies/Agriculture deptts./Agro industry/Private entrepreneurs/NGOs in managing/running plant
Evaluation of proposal	Expert Committee with representatives from ICAR/Engg. Institutions/Concerned Ministries

Note : This is an ongoing scheme since VIIIth Plan. Similar scheme proposed for the IXth Plan is under consideration by the Central Govt.

ANNEXURE – 21.2(C)

HUDCO's FINANCING

The waste management components which could be considered for HUDCO financing are:-

- Overall streamlined management of **municipal waste (solid and liquid)** comprising storage, collection, treatment/resource recovery and ultimate disposal components
- **Hazardous waste** like hospital waste, industrial waste generated within municipal/urban/semi-urban areas.
- Resource Recovery e.g. Compost, fuel, energy etc.
- Recycling which forms part of an integrated waste management project

ELIGIBLE AGENCIES

- Urban Local Bodies - Private Companies (registered) - Non Governmental Organizations (registered)	- Development Authorities - Health Care Establishments in the public/private sector - Co-operative/Joint sector/Public sector companies

FINANCING PATTERN

HUDCO's financing pattern for waste management schemes is given below:

INTEREST RATE *

Govt. guarantee Schemes	**14.0%/14.5% for 10/15 years**
Non-Govt. Guarantee Schemes	**14.5%/15.0% for 10/15 years**
DOCUMENTATION CHARGES	**Rs/10,000 (FLAT RATE)**
FRONT END FEE	**1.25% ON LOAN AMOUNT.#**

EXTENT OF FINANCING	**UP TO 70%**
SECURITY (An appropriate package with one or more of the given components	**BANK GUARANTEE** **GOVT. GUARANTEE** **MORTGAGE** **HYPOTHECATION** **COLLATERAL SECURITY** / **Corporate Guarantee** / **Personal Guarantee** / **Escrow Accounts** / **Post dated cheques**

NOTE :

1. ** The interest rate is net and is to be increased by 0.5% for gross- to be allowed as rebate for prompt payment*

2. ** For Bagasse based Co-generation projects which are considered under Demonstration programme of Ministry of Non-Conventional Energy Sources, the interest rate may be reduced by 2% subject to approval by the MNES.*

3. *# Rebate of 0.25% if legal documentation is completed within 4 months (6 months in respect of schemes of North East Region, Andaman, Nicobar Islands & Lakshadweep.*

AN EXAMPLE : FINANCING HOSPITAL WASTE MANAGEMENT SCHEMES BY HUDCO

HUDCO, under its Urban Infrastructure Financing Schemes finances hospitals and other health care establishments (Social Infrastructure category). It also finances a wide range of waste management schemes.

Eligible Agencies

⇒ Development Authorities

⇒ Municipal Corporations/Councils

⇒ Health Care Establishments (public / private sectors)

⇒ Private Companies/Agencies, NGOs etc.

Financing Pattern

Rate of interest : Schemes having Govt. Guarantee --14.0 / 14.5 % for 10/15 years
(net) Sch. Not having Govt. Guarantee – 14.5 / 15.0 % for 10/15 years

Extent of financing : Up to 70% of the project cost

Front end fee : 1.25%, Documentation charges : Rs. 10,000 (at a flat rate)

Security for the loan : An appropriate package with one or more of the following Components

- Bank Guarantee
- Govt. Guarantee
- Mortgage
- Hypothecation
- Collateral security :
  1. Corporate Guarantee
  2. Personal Guarantee

3. Escrow Accounts
4. Post dated Cheques

Eligible Components

Under this guideline only those schemes would be considered which strictly conform to / comply with the requirements of the Bio-medical Waste (Management and Handling) Rules, 1998 of the Ministry of Environment and Forests, Government of India, because of the highly infectious and hazardous nature of the waste and specialized management system required.

HUDCO gives priority to integrated hospital waste management projects for cities / towns including their suburbs so that the benefits are optimal. These may also be hospital based provided favourable / appropriate conditions are available. However, individual components of integrated hospital waste management projects may also be considered for financing on a case to case basis.

HUDCO would also prefer to have a proper waste management system incorporated at the planning stage of a hospital / any other health care establishment so that proper segregated storage area, separate waste movement corridors, collection area, treatment facility (in case treatment is planned to be done within the hospital premises) etc. can be effectively planned.

The waste management components which could be considered for HUDCO financing are:

- Overall streamlined management of hospital waste (solid and liquid) comprising storage, collection, treatment and disposal components within a hospital.

- Storage bins(preferably with color coding), special boxes for storing used sharps, specialized trolleys for carrying medical waste, covered vehicles for transport of medical waste within the hospital premises, any specialized equipment necessary for safe and hygienic containment, safe sealing of packages containing hazardous material etc.

- Treatment facility such as incinerator, micro-wave equipment, autoclave etc. Essential accessories, such as boiler for autoclave may be included. The specifications have to be strictly in accordance with the rules cited above. The health care establishment has also to ensure that the use of any particular treatment option would also be according to the above rules and that any piece of equipment would not be used for treatment of a type of waste for which it is not recommended.

- Common treatment and / or disposal facility for the whole or part of a city / town. This may include the treatment plant (strictly according to the above rules), its equipment, essential accessories (e.g., boiler), infrastructure (essential for the treatment), development of secured landfill for the ultimate disposal of the treated waste, such as, ash from incinerator, treated waste from microwave / autoclave facility etc. Administrative building or any other building (except the plant) will not be financed under this scheme. Such buildings may be considered under HUDCO's Social Infrastructure of Commercial Schemes as the case may be.

- Specialized covered vehicles for transport of hazardous bio-medical waste to the common facilities / designated disposal areas (such as secured landfill meant for the specific purpose).

The following aspects would be given special consideration:

- Complete systematic planning of hospital waste management incorporating measures to consciously reduce waste, segregation of hazardous and non-hazardous categories of hospital waste and their storage in colour coded bags / containers, separate storage of sharps in specialized containers, proper movement routs for the waste etc.

- Beneficial environmental impact including pollution control measures

- Use of standard equipment and field tested technology
- Proper institutional arrangement, allocation of specific duties and accountability.

- Regular training of personnel at different levels (administrative, medical, para-medical, cleaning staff etc.)

- Monitoring of waste management services

- The proposed system should preferably be the best possible option for the particular situation and site condition.

CHAPTER 22

ENVIRONMENTAL AND HEALTH IMPACT ASSESSMENT

22.1 INTRODUCTION

There are potential risks to environment and health from improper handling of solid wastes. Direct health risks concern mainly the workers in this field, who need to be protected, as far as possible, from contact with wastes. There are also specific risks in handling wastes from hospitals and clinics. For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats.

The most obvious environmental damage caused by municipal solid wastes is aesthetic, the ugliness of street litter and degradation of the urban environment and beauty of the city. More serious, however, and often unrecognised, is the transfer of pollution to water, ground water. Air pollution can be caused from the inefficient burning of wastes, either in open air, or in plants that lack effective treatment facilities from the gaseous effluents.

Uncontrolled hazardous wastes from industries mixing up with municipal wastes create potential risks to human health. Traffic accidents can result from toxic spilled wastes. There is specific danger of concentration of heavy metals in the food chain, a problem that illustrates the relationship between municipal solid wastes and liquid industrial effluents containing heavy metals discharged to a drainage/sewerage system and /or open dumping sites of municipal solid wastes and the wastes discharged thereby maintains a vicious cycle.

Municipal Solid Waste Management System involves various activities like storage, collection, transportation, disposal etc. These activities even if properly controlled and with proper precautionary measures adopted, may have adverse impact on land, water and air environment, human and environmental health, aesthetics and quality of life. The Environmental and Health Impact Assessment may help in assessing the potential adverse effects of these activities and in formulation of precautions which could prevent these effects from taking place.

There are already several World Health Organization documents that describe or review the potential environmental and health impacts of development activities and environmental change.

22.1.1 Need for Environmental And Health Impact

Epidemiological studies have shown that a high percentage of workers who handle refuse, and of individuals who live near or on disposal sites, are infected with gastrointestinal parasites, worms and related organisms. Contamination of this kind is likely at all points where waste is handled.

Although it is known that vector insects and rodents can transmit various pathogenic agents (amoebic and bacillary dysentery, typhoid fever, salmonellosis, various parasites, cholera, yellow fever, plague and others), it is often difficult to trace the effects of such transmission to a specific population.

During the last decade of the 19^{th} century as well as during the 5 initial years of 20^{th} century, millions of people died due to Bubonic Plague in India, which had linkages to poor management of Solid Waste. More recently a study by the US Public Health Service has demonstrated the relationship of 22 human diseases to improper solid waste management[6].

The organic fraction of Municipal Solid Waste is an important component, not only because it constitutes a sizable fraction of the solid waste stream, but also because of its potentially adverse impact upon public health and environmental quality. A major adverse impact is due to its attraction of rodents and vector insects for which it provides food and shelter. Impact on environmental quality takes the form of foul odors, unsightliness, land, water, air and noise pollution. These impacts are not confined merely to the disposal site. On the contrary, they pervade the area surrounding the site and wherever the wastes are generated, spread or accumulated.

Unless an organic waste is appropriately managed, its adverse impact will continue until it has fully decomposed or otherwise stabilized. Uncontrolled or poorly managed intermediate decomposition products can contaminate air, water and soil resources.

Most development activities are expected to have a beneficial effect on human health by increasing the resources available for food, education, employment, water supply, sanitation and health services. Proper management of municipal solid waste should have minimum effects on environment and health impacts.

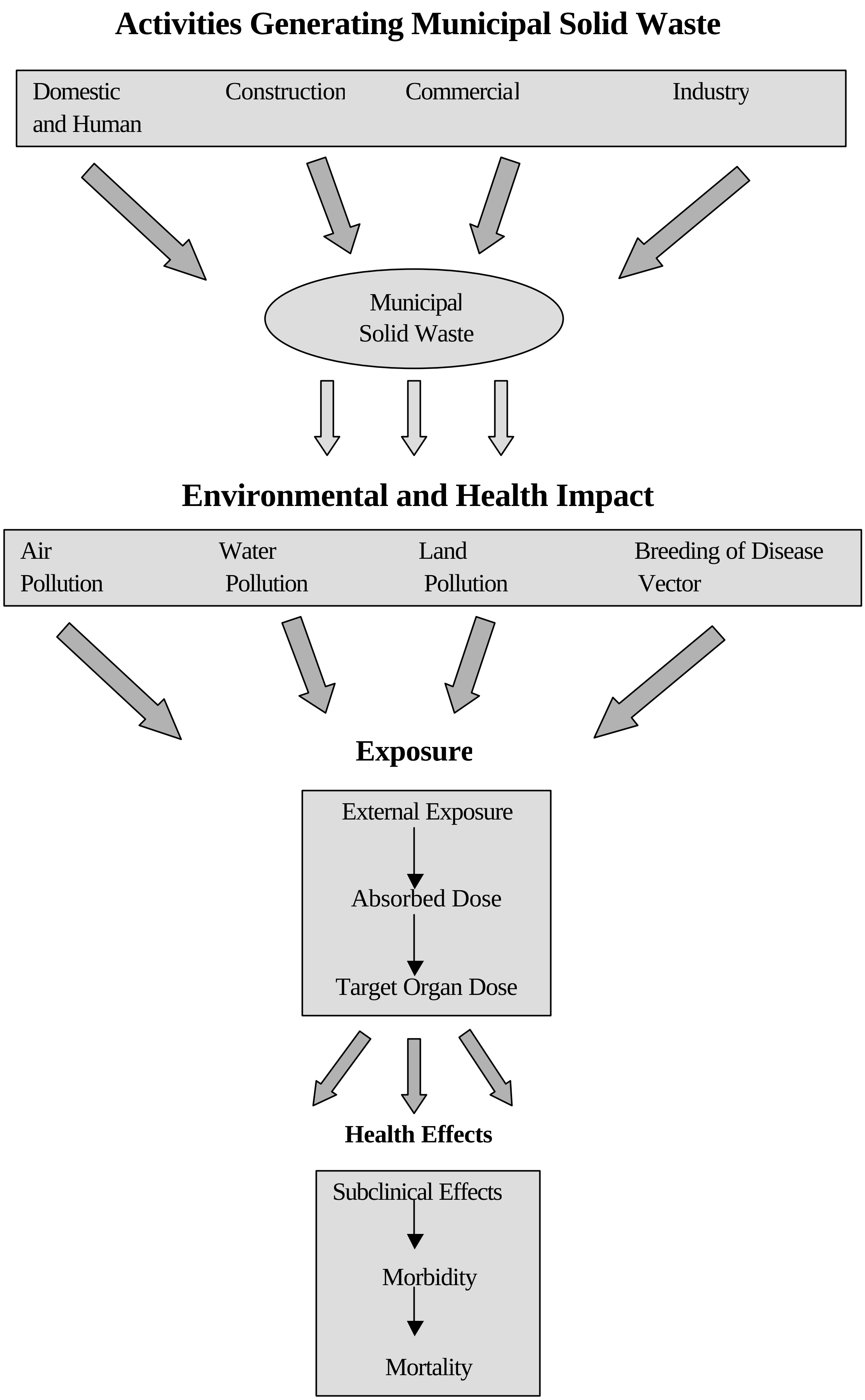


Fig.22.1 Impact of Municipal Solid Waste on Environment & Health

Environment and Health Impact Assessment of Municipal Solid Waste Management is intended to identify and predict the impact of these activities and to suggest preventive measures as appropriate on the environment and on people's health and well being and to interpret and communicate information about the impacts.

22.2 THE SIGNIFICANCE OF ENVIRONMENTAL AND HEALTH IMPACT ASSESSMENT (EHIA)

The significance of Environment and Health Impact Assessment is aimed at improving the information support for proper management of municipal solid waste.

Infrequent collection and rapid decomposition of wastes provide an attractive feeding and breeding site for flies, rats and other scavengers. Human and animal faecal matter or hospital wastes are often mixed with the refuse. Vectors and pathogens multiply. Domestic and on occasion industrial, solid wastes are disposed of in open spaces within residential areas.

Collection and disposal of refuse can consume up to 50% of a municipal operating budget. In many otherwise good systems, only 50-70% of the refuse is regularly collected. The problem is organizational rather than technical. Refuse disposal is often a non-profit making business and thus is treated as an unwanted side-effect of development. Attention should be paid to storage, collection, transport, and intermediate transfer to bulk transport and final disposal.

Estimated Number of rag-pickers (waste collectors) in a few cities in India

- Mumbai : 100,000; Delhi : 75,000; Calcutta: 40,000; Ahmedabad: 30,000; Chennai: 30,000; Bangalore: 25,000; and Jaipur: 10,000.

In many places waste recovery is an important unorganized private industry employing many thousands of scavengers who may live or work on refuse dumps. They are referred to as human scavengers or waste pickers and are frequently ignored in urban project plans although their activities may be vital to the life of the city. Many consist of abandoned children and destitute families. They live and work under extensive health risks, which are largely undocumented, and suffer severe exploitation and deprivation. Possible health hazards include raised levels of infant mortality, hand and leg injuries, intestinal and respiratory infections, eye infections, lower back pain, malnutrition, skin disorders and exposure to hazardous waste[7,8]. Water supply, for drinking and washing, and sanitation facilities are usually very poor at dumpsites. Health and welfare facilities are required.

Health Status of the Refuse Workers

No. Examined	Refuse Workers 50		Control Group 70	
	Incidence		Incidence	
Disease	**No.**	**%**	**No.**	**%**
Aneamia	12	24	11	16
Gastrointestinal Diseases	19	38	18	26
Respiratory Diseases	31	62	17	24
Skin Diseases	16	32	10	14
History of Jaundice	21	42	4	6
Trachoma	11	23	-	-

Source : CPHERI (NEERI) Report (1971): Studies on health of refuse workers in Trivandrum

Waste collectors may make a substantial contribution to urban waste management. They may reduce the volume of waste by 10-20%. However, private collection at source may only operate in the wealthy areas where refuse contains items of value. Observers agree that the issue of waste collectors cannot be evaded. Their positive role in the management of municipal solid waste should be recognised and their lot improved.

COMMUNICABLE DISEASE

Houseflies may be important in the transmission of enteric infections, particularly those responsible for infantile diarrhoea and dysentery.

Disease transmission by houseflies is greatest where inadequate refuse storage, collection and disposal (leading to increased breeding) is accompanied by inadequate sanitation. Thus flies gain greater access to human faeces and then to food. Refuse must be collected daily to prevent fly breeding.

NON-COMMUNICABLE DISEASE

Once collected in poorly operated disposal sites, rubbish may contaminate groundwater with nitrates, heavy metals and other chemicals. Incineration of wastes may pollute the air with particulates and oxides of sulphur and nitrogen. The slag and ashes from incinerators may result in leachates that are rich in heavy metals and other potentially toxic substances.

INJURY

Combustible gases will be generated from waste tips for more than 20 years and these travel under roads and through ducts to create a hazard in buildings and land fill sites.

People collecting rubbish may be injured by sharp objects including glass, metal and wood. These may lead to puncture wounds and lacerations which may become infected and cause serious morbidity. Composted solid waste can cause injury to farmers as sharp objects are not always properly removed.

AESTHETICS ASPECTS

Foul odor is emitted at the disposal site due to continuous decomposition of organic matter and emission of methane, hydrogen sulphide, ammonia, etc. The problem is intensified if proper mitigation measures are not adopted.

Odor is also emitted at the collection points if quick removal of wastes is not practised. Spreading of the waste in the area adjacent to the dustbin due to activity of ragpickers cause degradation of aesthetic quality. Uncontrolled disposal and open burning of wastes at the landfill sites create poor vision.

Domestic rats, birds and other scavenging animals act as reservoirs for many organisms transmissible to people, including plague, forms of typhus, leptospirosis, trichinosis, psittacosis, salmonella infection and bovine tuberculosis.

Chemical control of both houseflies and rodents is not very effective because of widespread resistance. The essential basis of control remains denial of access to food and harborage, by covered storage and efficient removal.

Aedes mosquitoes, vectors of dengue and yellow fever, breed prolifically in discarded containers that trap rainwater. Culex mosquitoes, vectors of filariasis, breed n polluted stagnant water. Such breeding sites often occur where drains are choked by solid waste.

22.2.1 EHIA broadly involves:

1. Identification of environmental and health hazards;
2. Interpretation of environmental and health risk;
3. Management of environmental and health risks.

The 3 steps as outlined above need to be followed for all the five main project stages of the municipal solid waste management. These are:

1. Pre-project;
2. Implementation/Construction;
3. Early Operation;
4. Late Operation (after 10 years)
5. Closing and final treatment of the site.

The Operational procedures required by a regulating agency as prescribed by Government to achieve these steps are:

1. Initial screening of the project for environmental and health hazards;
2. Initial environmental impact statement;
3. Initial health examination, or rapid appraisal;
4. Health Impact assessment
5. Prospects for environmental management plan; and
6. Prospects for health risk management

The initial screening process identifies the environmental and health hazards normally associated with the kind of municipal solid waste management project in its stages as appropriate in the specified location. For example higher incidence of anaemia, gastrointestinal diseases, respiratory diseases, skin diseases, jaundice, trachoma, and eosinophilia was reported by the National Environmental Engineering Research Institute, Nagpur in 1970 as per a short term study of the health status of municipal refuse workers in Trivandrum in Kerala. The system of storage, collection, transportation and disposal of hospital waste was observed to be far from satisfactory.

The initial environmental impact statement by the project proponent should include a project screening procedure to prevent planning delays and establish priorities and scoping procedure to ensure that all interested parties are consulted and all aspects of impact as required are included. The next activity will lead to the Environment Impact Assessment based on initial environmental impact statement report and need for a full health impact assessment.

The Initial Health Examination (IHE) or rapid appraisal, uses existing information to interpret the health hazard as a health risk. It should be carried out by a qualified medical officer responsible for health impact assessment. The distinction between a health hazard and a health risk is important and is discussed below. At the end of this step, the project receives a health impact classification. The classification may indicate the need for a full health impact assessment.

A full environmental and health impact if required is to be carried out by specialist consultants as appropriate according to terms of references (TORs) to be drawn up by the authorised municipal solid waste management manager. It involves detailed field studies and is more rigorous, expensive and specific form of assessment as would be required as per initial environmental impact statement and initial health examination, or rapid appraisal report.

The steps discussed above need to be followed and applied as would be necessary for a particular project in a particular location keeping in view that the development project on municipal solid waste management are not delayed unnecessarily by lengthy or expensive investigations.

Environment and health risk management should include both health safeguards and mitigation measures. Project monitoring and health surveillance are also required and should be ensured as a part of operation and maintenance of municipal solid waste management.

22.3 TYPES OF ENVIRONMENTAL AND HEALTH HAZARDS

Municipal Solid Waste Management activities have a potential to cause air, water, land and noise pollution besides affecting aesthetics and creating health hazard which again has a potential to cause disease or infirmity. Potential contribution of field parameters and matrix indicating site effect on each of six basic environmental and health parameters are depicted in **Table 22.1.**

Health hazards may be further ranked according to the magnitude of their consequences. A **major consequence** would include multiple loss of life and chronic disability. A **moderate** consequence would include some loss of life and extensive temporary disability. A **semi-moderate** consequence would include illness and temporary disability. A project activity which has a high risk of major hazard would be unacceptable. A minor hazard of low risk may be unimportant.

Although health must be viewed in its totality, for the purposes of impact assessment, it is necessary to consider specific hazards and their components. The process of assessment consists of ranking these as likely to increase or decrease in magnitude as a result of improper or proper management of municipal solid waste. The economic cost of the change in health hazard may be viewed as the additional cost of restoring to their previous state of health all the concerned individuals who succumb to the additional hazard, plus the loss of production and productivity.

It would be convenient to divide the environmental and health hazards associated with solid waste into five main categories as listed in Table **22.2.**

Table 22.1: Proportional Contribution of Field Parameters (Matrix)

Sl. No.	Factor (1)	Air quality (2)	Water quality (3)	Land use (4)	Aesthetics (5)	Noise (6)	Health (7)
1.	Refuse placement			0.7	0.3		
2.	Compaction			1.0			
3.	Periodic cover	0.3.	0.3		0.4		
4.	Final cover			0.8	0.2		
5.	Surface finish		0.2	0.4	0.4		
6.	Blowing litter				1.0		
7.	Bulky items			0.4	0.6		
8.	Burning	1.0					
9.	Vectors						1.0
10.	Toxic hazardous waste	0.1	0.5	0.4			
11.	Ground water		1.0				
12.	Surface water		0.8		0.2		
13.	Drainage	0.2	0.6	0.2			
14.	Dust	0.6			0.4		
15.	Site visibility				1.0		
16.	Approach to site				0.5	0.5	
17.	Site noise					1.0	
18.	Land type			0.6	0.4		
19.	Organization			1.0			
20.	Precautions against fire, wind etc.	0.3	0.3		0.3		0.1

Source: Manual on SWM prepared by NEERI, November 1996

Table 22-2: Types of Environmental & Health Hazards

Environmental & Health Hazards	Examples and Causes
Environmental Pollution	Air quality, water quality, land use, noise
Communicable disease	Gastrointestinal disorders, diarrhoea, respiratory infection, skin diseases, jaundice, trachoma, eosinophilia etc.
Non-Communicable disease	Poisoning, hearing defects/loss, dust
Injury	Occupational injury by sharps, needles, glasses, metals, wood, violence etc.
Aesthetics	Odour, visibility, dust etc

Each stage of proper project cycle provides opportunities to safeguard environment and health. For example:

- Location vis-à-vis vector borne disease
- Design affects abundance of vector breeding sites
- Construction may mix communities in ways that favour a range of communicable/non-communicable disease transmission.
- Improper collection, storage, transportation and disposal create conditions for environmental pollution, communicable, non-communicable disease, injury and occupational health risks.

22.4 ENVIRONMENTAL AND HEALTH HAZARDS IDENTIFICATION

For environmental and health hazards identification two basic questions should be kept in view:

1. Is the activity in a health sensitive location? (to be identified from existing information, maps, foci and provincial/local health records);
2. Does the activity contain health hazardous components (such as hazardous and hazard causing activities/operations, materials, equipment etc.)

Existing local reference information that can be consulted to answer these questions.

Environmental and health identification of the following activities/components need to be carefully examined:

1. Design, storage methods of collection bins;
2. Frequency of collection particularly putrescible organic matter;
3. Environmental status of collection points and disposal sites;
4. Loading/unloading of wastes in the vehicles at the collection points and disposal sites;
5. Sorting out the recyclable materials;
6. Open burning of solid waste; (whether the practice leads to increase in concentration of suspended particulate matter carbon monoxide, sulfur dioxide, hydrogen sulphide, nitrogen oxide, dioxins and furons in the surrounding area);
7. Design of and operation collection vehicles;
8. Design and operation of landfill sites
9. Compaction and coverage of solid wastes at the landfill site (to prevent escape of methane gas at the landfill site);
10. Breeding of flies, mosquitoes, cockroaches, rodents, pigs, stray dogs (they play important role in the spread of disease)
11. Activities generating odor and aesthetic problems;
12. Activities/components which are potential cause of injury, violence etc.
13. Activities/components which are likely source of air, water, soil and noise pollution.
14. Periodical Personal Protective Clothings (PPC), Personal Protective Equipment (PPE) and health checkup of workers/staff engaged in various/activities of solid waste management

22.5 INITIAL ENVIRONMENTAL AND HEALTH EXAMINATION (IEHE)

After the project officer has expressed a concern about environmental and health impacts, an initial environment impact statement and initial health examination, or rapid appraisal, is required to classify the health impacts according to **Table 22.3**.

Table 22-3: Health Impact Classification

Classification	Interpretation
A	Significant environmental and health impacts, mitigation difficult or requires special budget
B	Significant environmental and health impacts, mitigation practical without special budget
C	No significant environmental and health impacts to local communities and affected populations

The process uses available information such as published and unpublished reports and interviews with local specialists. It may involve a site visit. It should be undertaken by a team of experts including also a medical officer responsible for impact assessment.

In order to make this classification it is necessary to:

- Rank the change in health risks attributable to the project for a range of health hazards;
- Consider possible mitigation measures;
- Rank the possible mitigation measures by cost, practicality and acceptability.

In order to rank environmental and health risks associated with environmental and health hazards it would be appropriate to construct a project profile. The profile would identify the current status of the community, their environment and their health services. It would also identify how the status may be changed by proper solid waste management. The three main sub-components should be considered. These are:

1. **Vulnerable communities**: Identify the communities who may be exposed to the environmental and health hazards and why they are vulnerable;
2. **Environmental factors**: Identify the pathways by which the exposure to the health hazards may occur;
3. **Capability of health protection agencies**: Identify the agencies with a responsibility for safe guarding health together with their strengths and weaknesses.

The conclusion of this process can be recorded in a summary health impact assessment as outlined in **Table 22.4.**

Table 22.4: Summary Health Impact Assessment Table

Health Hazard	**Community Vulnerability**	**Environmental factors**	**Capability of health protection agencies**	**Health risk attributable to the project**
Communicable disease				
Non-communicable disease				
Injury				
Aesthetics aspects				

Table 22.4 can be expanded as appropriate to include a list of specific health hazards under each hazard category.

22.5.1 Vulnerable Communities

Proper management of municipal solid waste at all stages of the project is expected to be overwhelmingly beneficial to the health and sustainable development as well as economic well-being of many communities. Others, the vulnerable communities e.g. waste collectors, field staff to be engaged in different activities relating to solid waste management such as collection, storage, transportation and at disposal sites, may experience some adverse health consequences. **Table 22.5** indicates the nature of some vulnerable communities.

Community vulnerability is determined by factors such as :

- Natural and acquired immunity to communicable diseases;
- Poverty
- Hazard avoidance behaviour
- Social status
- Personal hygiene

Table 22.5: Examples of Vulnerable Communities

Vulnerable groups	Health Hazards or exposure
Project workforce	Communicable disease, non-communicable disease, injury
Migrant workers	Communicable disease, non-communicable disease, injury
Rag-pickers	Communicable disease, non-communicable disease, injury
Beggars/street children	Communicable disease, non-communicable disease, injury
Sweepers	Communicable disease, injury
Field staff for collection, storage, loading and unloading of solid wastes	Communicable disease, injury
Field staff engaged in sorting of solid wastes	Communicable disease, injury
Vehicle drivers	Communicable disease, injury
Field staff engaged in sorting of solid wastes	Communicable disease, injury
Field staff engaged in recycling/re-use of solid wastes	Communicable disease, non-communicable disease, injury
Field staff engaged in sanitary landfilling sites	Communicable disease, non-communicable disease, injury
Workforce engaged in handling Bio-medical waste	Communicable disease, non-communicable disease, injury
Field staff engaged in operation of incinerators, Auto-calve, microwave etc. for treatment of bio-medical wastes	Communicable disease, non-communicable disease, injury
Local dependents of field staff engaged in solid waste management	Communicable disease
Distant dependants	Communicable disease imported by circulating labour
Slum dwellers	Communicable disease, non-communicable disease, injury
Periphery	Non-communicable disease due to pollution
Down stream/down wind	Non-communicable disease due to pollution

Immunity is affected by factors such as prior exposure, vaccination, age and gender. Poverty affects health services, hazardous occupations. Hazard avoidance behaviour is partly determined by knowledge, attitude, belief and practice (KAP). Short surveys provide a practical tool for determining this component of community vulnerability.

CHECKLIST

- Have all communities associated with pre-project, implementation/construction, early operation, late operation phases of municipal solid waste management been identified?
- Do any of them appear to be especially vulnerable to the project as a result of location, behaviour, exposure, age, gender or cultural reasons?

22.5.2 Environmental Factors

The community is exposed to the environment through location, occupation and behaviour. The environment is changed by the project. New health hazards may be introduced and old health hazards may disappear. The changes may take place immediately or over a timescale of ten or more years.

Hot, humid and moist environment is congenial for most of the disease causing organisms. Various components like air, water, land, noise and socio-economic are considered during environmental and health impact studies.

Environmental factors which have potential linkages with solid waste management at its different phases and health are:

1. Temperature;
2. Rainfall;
3. Humidity;
4. Wind (speed and direction);
5. Air quality;
6. Water quality;
7. Physical and chemical properties of soil; (particularly for minimising leaching from landfill sites, soil-microbe activities for composting)
8. Land use
9. Noise
10. Aesthetics

CHECKLIST

- Are there any features of the environment which promote exposure to health hazards?
- Are there any practical environmental changes that provide safeguards and mitigations?

22.5.3 Responsibilities of Protection Agencies

For protection of environment and health in India several agencies are jointly responsible. The health service is responsible for human health including routine health data collection, collation, analysis, interpretation, curative and preventive measures. Environmental protection agencies (Central and State Pollution Control Boards) regulate, enforce implementation and monitor compliance with water and air quality, waste emissions, noise regulations. Ministries of health and labour are responsible for occupational health and safety regulations.

Municipalities and Urban Local Bodies are responsible for proper management of municipal solid waste. At State and Central levels urban development departments and Ministry of Urban Affairs and Employment are the nodal agencies at the respective levels.

Environmental protection agencies' main function is enforce implementation of the regulations. They are best at regulating and enforcing pollution prevention and control regulations. They have little or no experience of regulating communicable, non-communicable diseases, occupational health, injury and safety. Health agencies have a little regulatory function.

Health impact assessment of development projects including municipal solid waste management needs a coordinated multi-disciplinary approach and missionary zeal. Keeping in view serious health risks of municipal solid wastes, several expert committees recommended strengthening capabilities of the health agencies to take active part and responsibility for health impact assessment..

CHECKLIST

- Do staff engaged in municipal solid waste management have realistic access to preventive and curative health services based on distance, cost and time travel, opening times, protective clothing supplies, training facilities, trained personnel availability etc?

- Are health centre diagnostic facilities, for staff engaged in municipal solid waste management, functional, quality controlled, timely?
- Does the staff engaged in solid management activities have functional water supplies and latrines, access to facilities for cleaning/disinfection of implements/ equipment/vehicles and are personnel paid regularly?
- Is routine health surveillance data accurate, displayed, used in decision-making?
- Are the health services oriented towards monitoring, evaluation and responding to field needs?
- Do the capabilities of health and environmental protection agencies require strengthening?
- Is the Ministry of health represented in procedure, project design, implementation, operation and maintenance, monitoring and evaluation, health and environment impact assessment?

22.6 PROJECTS REQUIRING DETAILED ENVIRONMENTAL AND HEALTH IMPACT ASSESSMENT

At this stage project can be classed into the categories listed in **Table 22.5.1** keeping in view proportional contribution of field parameters and matrix list in **Table 22.2.1.**

The screening process would help to establish as to whether the project would require a full EHIA. Various methods for screening are available.

The project officer must decide whether a full environment and health impact assessment (EHIA) requiring the service of a specialist consultant, is necessary. The decision will depend on the available experience and expertise within the responsible agency.

The project threshold method relies upon the establishment of threshold values for key factors of the project such as size, cost, infrastructure requirements etc. which if exceeded, qualify the project for a detailed EHIA.

The sensitive area method involves screening of projects based on carrying capacity of the environment in relation to the degree of disturbance of the location of the project in an identified environmentally sensitive area and initial environmental and health examination as discussed in para 22.4.

In the positive-negative list approach, projects are screened with the help of positive list that identifies activities which require detailed EHIA if significant impacts are indicated.

The screening test method comprises questionnaires in which likely impacts of projects are identified by seeking answers to a series of questions relative to impact types.

If an EHIA is required, appropriate (TORs) need to be prepared for a specialist consultant. The Initial Environmental Impact Statement and Initial Health Examination would have identified the environmental and health hazards and communities that the TORs should address. The Environment and Health Risk Assessment would seek to establish in more detail whether changes in the principal health risks can be attributed to the project. Mitigation measures should be considered.

Possible mitigation measures could be grouped into the following classes:

- Opportunities for modifying project location
- Opportunities for modifying project design
- Opportunities for modifying project operation and maintenance.
- Opportunities for incorporating environmental management measures
- Opportunities for strengthening health services
- Need for monitoring and surveillance (how will the data be used?)

Each mitigation measure on the list should be roughly classified in terms of:

- Affordability (is it cheap to build?)
- Sustainability (is it cheap to maintain? Is it easy to operate?)
- Acceptability (is it socially acceptable to the local community?
- Accessibility (is it physically, socially or economically accessible to the vulnerable communities?)
- Cost-effectiveness (could the resources needed for this mitigation measure be more effectively employed elsewhere?)

22.6.1 Components of EHIA

As a result of the identification of environmental and health hazards and Initial Environmental and Health Examination as outlined in paras 22.1.3 and 22.2, 22.3 and 22.4, the EHIA can focus in depth on a small number of significant health hazards. During the feasibility study, the consultant should assess the health risk associated with each health hazard at each project stage and for each vulnerable community. The assessment is concerned with the change in exposure associated with the project: identifying the communities that will be exposed and the nature, magnitude and likelihood of that exposure. The consultant should also establish the capabilities of existing protection agencies, including the health service, to monitor, inform, safeguard and mitigate environmental & health risk. The description of the existing conditions is often referred to as profiling.

The conclusions of the assessment must be presented to the decision-makers in a format which will enable them to use the information effectively. The Summary **Table 22.4** used for Health Impact Assessment is recommended for EHIA

The cycle of hazard identification and risk interpretation may have to be repeated. First, as a rapid appraisal and second as a detailed study of the major risks. The feasibility study should provide the information required for negotiating changes in project plans or operation to safeguard health.

22.6.2 Scope

The primary consideration in effective and timely EHIA is to limit the scope of study to the range of relevant project alternatives and issues. This activity is called as scope and involves identification of the most significant impacts from an exhaustive list of various impacts. Criteria such as magnitude, extent, significance and sensitivity are used to arrive at an appropriate decision.

Terms of Reference (TORs) for EHIA will include the hazards to be addressed, the communities of interest, the effects likely to be felt by the communities within and without the neighbourhood, the spatial boundaries (since the influence of the project may extend far beyond the project site e.g. formal and informal labour having linkages with distant communities, vector breeding on site may disperse downwind, effluent discharge into streams and air flows may be carried many kilometers, toxins may accumulate in food-chain and affect health of communities) and temporal stages for which a prediction is required.

Discussions may be held with agencies concerned with the project. Public meetings may be organised. Community participation should be actively sought out.

22.6.3 Steps involved in EHIA studies

Steps involved in EHIA studies include:

1. Initial Screening
2. Scope
3. Collection Baseline Data
4. Identification of Impact
5. Prediction of Impact
6. Evaluation of Impact
   a) Primary
   b) Secondary

The networks showing probable impacts identified due collection and disposal activities are depicted in **Annex-1** and **Annex-2**.

22.6.4 Model Terms of Reference(s) for EHIA

A Model Terms of Reference for Environmental and Health Impact Assessment could include the following components:

Introduction

This states the purpose of the terms of reference, the type of project to be assessed, and the implementing arrangements for the environmental and health impact assessment.

Background Information

This provides a brief project description with the objectives, the status and timetable, and the project proponent. Related projects within the region must be identified.

Objectives

This states the general as well as specific objectives of the environmental and health impact assessment in relation to the project preparatory activities such as feasibility studies (planning, design and execution, operation and maintenance).

Environmental Requirements

This section identifies regulations and guidelines that will govern the assessment such as operational directives, municipal, state, national laws or regulations, and specific regulations of other funding organizations involved in the project. The requirement for health impact studies should be included in the EIA regulations.

Study Area

This specifies the boundaries of the study area for the assessment. It should include the human communities downstream and downwind of the project. The EHIA boundaries could go beyond the EIA boundaries, which are usually the watershed or airshed.

Scope of Work

The health hazards and communities that require particular attention are obtained from the Summary **Table 22.4**. The consultant could be asked to refine the scope of work for contracting agency review and approval. Other agencies may be invited to comment and public meetings be held.

Health Risk Assessment

The consultant will assess the health risk associated with each environmental & health hazard at each activity. The assessment will include the following considerations:

Community Vulnerability

Identify each vulnerable community (examples of vulnerable communities listed in **Table 22-5**) to be affected by the project and assess the nature, magnitude and likelihood of exposure. Estimate the prevalence rate of each hazard in each vulnerable community from health sector records and/or special survey.

Environmental Factors

Consider the environmental factors that may contribute to an increase in health risk and define mitigating measures as input to project planning, implementation, operation and maintenance. Estimate the magnitude of the factors.

Capability of Protection Agencies

Establish in more detail the capabilities of existing protection agencies, such as the environmental and health agencies, which have jurisdiction over the project site. The consultant should assess the limitations of existing data and recommend how to strengthen health information systems to meet requirements for health risk management.

Health Risk Management

The consultant may be asked to formulate a monitoring programme during the construction and operational stages that includes: a description of the work tasks, skills/tests/interviews, frequency, institutional and financial arrangements, justification/use of the monitoring data. The consultant should define the safeguards and mitigating measures required as inputs to the feasibility study.

Context for Health Risk Management

Account should be taken of the availability of resources and funds, whether there are any interest groups actively concerned about the project and its health impact, whether local environmental lobby groups exist, the attitudes of local authorities and government, and whether meetings have been held to promote changes in the project. Consideration should be given to any groups that may oppose change, and any groups whose support could be obtained in order to increase the prospect of protective/mitigating measures being applied.

Consultant Requirements

Ideally, the consultant would have previous experience of assessing the health impacts of development projects. However, the consultant must have specialist knowledge of the most significant health risks were identified during the Initial Environmental and Health Examination. If diverse health risks were identified then additional consultants may be required with specialist knowledge of each.

Reports, Duration and Schedule

This will specify the total period of the study, staff-months of experts, dates for consultation, periodic reports and other target dates.

Other Information

This will provide the consultant(s) with preliminary information on data sources, background reports and studies, and other relevant publications.

22.7 EHIA STATEMENT

The output from an EHIA will be EHIA Statement. This should be modeled on the Initial Health Examination. It should include a Summary Table similar to **Table 22.4**. This table should be supported by an explanation of each item.

22.8 ENVIRONMENT AND HEALTH RISK MANAGEMENT

The environment and health risk assessment should be presented to the project approval committee who must evaluate relative importance of the impacts which have been identified in a wider context, This will decide the priority to attach to the recommended safeguards and mitigation measures, negotiate resources and assign monitoring and surveillance tasks.

22.8.1 Environmental Management Plan

Environmental management plan is delineated in order to minimise adverse impact on the environment due to various activities involved in solid waste management. The various mitigation measures to be adopted during collection and disposal of wastes are as follows:

- It is preferable that the container and bins used for collection of waste should be of closed type so that the waste is not exposed and thus the possibility of spreading of disease through files and mosquitoes is minimised
- Collection system should be properly supervised so that quick and regular removal of waste from the dustbin is practised
- The workers directly involved in collection and disposal activities should be provided with goggles, gum boots, hand gloves, mask, etc.
- Soil cover should be applied over the compacted waste at the disposal site. The cover will prevent breeding of disease vectors and escape of gases of decomposition; minimise leaching, suppress foul odour, and provide better aesthetics
- Regular monitoring of carbon monoxide, methane and hydrogen sulphide should be carried out to check the emissions of such pollutants

- Open burning of waste should be discouraged
- Arrangement should be made for biogas recovery at the landfill site. The gases can be flared or utilised
- Piped water supply should be provided at the site for sprinkling of water to keep down the dust and for fire-fighting
- Continuous monitoring of ground water quality adjoining the landfill site should be carried out
- The surface water run-off should be collected and safely treated and disposed off. This will prevent accumulation of water and avoid breeding of flies, mosquitoes
- Liners should be provided at the landfill site
- Leachate collection and treatment system should be provided at the landfill site
- Tree plantation on the completed section of the landfill site as well as around the landfill site should be carried out to reduce the dust emission and minimise adverse aesthetic impact. It will also help in minimising noise level in the surrounding
- Necessary first aid facilities should be provided to the working staff

Environmental management of waste to energy projects as described in Para 12.5 of chapter 12 and various environmental management issues relating to municipal solid waste landfills such as EIA for site selection, environmental investigation for site investigations and site characterization, design of environmental monitoring system, pollution prevention during operation, landfill quality assurance and quality control as highlighted in Paras 14.4.8, 14.5.5, 14.6.19, 14.8.4.6, 14.9.3 and 14.10 of the chapter 14 need to be properly addressed as appropriate for effective environmental management of municipal solid waste.

Municipal solid waste management projects, in particular, provide an opportunity for vector-borne disease control through environmental management. Environmental management for vector control consists of deliberate alteration of the environment, environmental factors or interactions between people and the environment designed to limit vector breeding, survival or human contact. The environment includes soil, water, vegetation and urban and rural settlements. The environmental factors include microclimate, chemical composition and vector behaviour.

Environmental Management for Vector Control can be summarized as follows:

- Permanent modification to the environment to inhibit vector breeding.
- Repetitive actions, to inhibit vector breeding.
- Changes in human behaviour and habitation which reduce breeding or exposure.
- Timely assessment of the health hazards to ensure that design changes can be incorporated in project plans and operations.

Some elements of the first three are discussed in WHO's "Manual on Environmental Management for Mosquito Control"[17]. They include the following measures:

- Drainage of urban and rural settlements and irrigation systems;
- Alteration of river, reservoir and other water impoundment levels by sluicing and flushing;
- Alteration of water salinity;
- Removal of favourable and planting of unfavourable vegetation for vector breeding;
- Changing conditions of exposure to sunlight and shade;
- Land filling and leveling;
- Alternate flooding and drying of rice fields;
- Destruction of water-filled containers; screening of cisterns;
- Improvements in sanitation, sewerage and solid waste management systems;
- Siting human settlements 2km or more from vector sources;
- Land zonation;
- Using livestock as diversionary hosts;
- Using bednets and house screens;
- Management of irrigation water;
- Avoidance of infested water for domestic use or recreation.

Many of these measures cannot easily be incorporated in project design or operation unless previously identified through health impact assessment. Environmental Management requires collaboration at all levels between different stakeholders, the pooling of expertise and involvement of the community.

22.8.2 Health Risk Management

Health risk management consists of incorporating safeguards and mitigation measures in project design and operation. Safeguarding entails proposing modifications to project plans and operations and ensuring that the capability exists for effective mitigation. This could include strengthening of protection agency capabilities.

Mitigation entails vigilant monitoring for the lifetime of the project accompanied by appropriate and timely response to increasing health risks. Monitoring depends on an adequate health information system. Response may depend, for example, on stocks of protective equipment and their dissemination and use.

In Municipal Solid Waste Management project a hierarchy of risk management has been defined. These are:

- Elimination of the source of hazard;
- Substitution of hazardous processes and materials by those which are less hazardous;
- Geographical or physical isolation of hazards from vulnerable communities, for example by land zonation;
- Use of engineering controls to reduce the health risk. For example, collection containers and bins should be closed type so that spreading of disease through flies and mosquitoes is minimised;
- Adoption of safe working practices such as regular equipment maintenance;
- Use of personal protective equipment, such as rubber gloves.

Table 22-6 indicates some of the actions and concerns that should be addressed during each project stage. The objective is to alert the development planner to issues that should be addressed at each project stage.

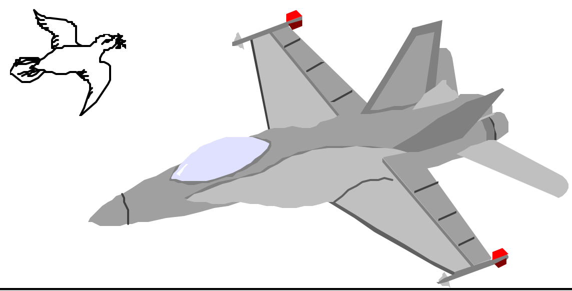
Where the community is exposed to a hazard as a result of occupation, mitigation may be achieved primarily by occupational safety measures and continuous health education. Where the community is exposed through its location, mitigation may be achieved primarily by reducing the hazard or relocation. At the planning stage land-use zonation and resettlement siting could be considered.

Table 22-6: Health Risk Management: some possible actions at different project stages

Project Stage	Surveillance and monitoring	Health service provision	Safety provision and preventive measures	Obtaining advice from the health sector about:
Location	Site specific health hazards, general health status of local communities, most common causes of morbidity and mortality, location and functioning of health services	Access to health services	Settlement siting	Disease foci, vector biology
Planning and design	Improve routine health service surveillance by retraining health information system, laboratory services	Health centre, trained personnel, drug supply, equipment maintenance , housing for health workers, casualty/ emergency unit as appropriate	OHS planning, traffic routing, environmental management	Communicable disease control, environmental management for vector control, environmental manipulation, environmental health
Construction	OHS monitoring, environmental health, water supply, sanitary system, drug supply, vector monitoring	STD clinic, distribution of condoms, health training casualty/ emergency unit, vector and other communicable disease control	Safety measures consistent with local economy, OHS training, traffic routing	Communicable disease control, environmental health
Operation	Routine medical examination, action oriented disease trend analysis, child growth monitoring, OHS monitoring, infant mortality monitoring, vector monitoring, casualty rates	Health education, immunization, obstetrics, training traditional health workers, food supplement programme, casualty/ emergency unit, access to health service outside working hours, vector and other communicable disease control	Safety measures consistent with local economy, OHS implementation environmental management	Communicable disease control, environmental management for vector control, environmental manipulation, environmental health, human behaviour modification
Opportunities for project enhancement	Health information system, diagnostic/ laboratory services	Healthy workforce is more productive and vice versa	Safer working methods, training, injury compensation	Intersectoral collaboration

22.8.3 Risk to Human Life and Property

Indiscriminate disposal of wastes attract birds, resulting episodes of bird hits to the aircrafts which in turn result in environmental risk to human life and property as can be seen from the data reproduced in the box shown below.



Solid waste dumped in an indiscriminate manner do attract various kinds of birds (vultures, kites etc) which float around for hours close to the air fields in search of food, thereby posing a serious hazard to aircrafts, operating at these airfields. The degree of hazard varies with the size of the bird and the speed of the aircraft. As most defence aircraft are single engined and fly at high speeds, they face maximum risk. At an average speed of about 900 kms per hour (which works out to about 15kms per minute) if a bird and an aircraft are on a collision course, the changes of sighting the bird and avoiding it are practically nil. Since most fighter aircraft are single engined, damage to the engine invariably implies loss of the aircraft and at times even of the pilot. Each year 3 to 4 aircraft are lost and 35 to 40 engines withdrawn. In fact in the last 5 years alone IAF has lost 12 aircrafts due to bird hits imposing a replacement cost of Rs. 2860 million. Besides this, bird hits also pose a threat to the life of the pilot and damage to life and property at the site of the crash.

22.9 PUBLIC INFORMATION AND PARTICIPATION FOR EHIA

22.9.1 The public should be made aware on the following aspects for environment and health surveillance:

- As far as possible faecal matter should not be allowed to mix with municipal refuse
- Hospital and municipal wastes should be handled separately

- Burning of refuse should not be permitted
- Discharging of waste into drains and open areas should be prohibited by law
- Solid waste should be handled once and its contact with workers minimised as much as possible
- Efforts should be made to remove solid waste from habitations regularly
- Regular medical check up of personnel handling solid waste should be carried out
- Health records should be maintained for the areas served under municipal solid waste management programme.

22.10 FINANCIAL ASPECTS

The ultimate goal of municipal solid waste management is to improve the quality of life of people, especially the underprivileged, the ignorant and the poor who cannot exercise their right to human dignity. The lack of attention given to human health, environment and safety issues cannot be attributed to cost factors.

22.10.1 Suggested Investment

Generally there has been a tendency to set up curative services to deal with problems created by a development project instead of setting in place appropriate preventive strategies as an integral part of the original development as has been amply demonstrated in the major development projects like irrigation and industrial projects which have propensity for creating malariogenic conditions. It is, therefore, recommended that generally about 1% of the project investment on MSWM may be considered for environmental and health impact assessment of municipal solid management.

CHAPTER 23

MANAGEMENT INFORMATION SYSTEM

23.1 INTRODUCTION

23.1.1 Objective

Good Municipal Solid Waste management practices is the key to keep a city clean. This requires collection of critical information which is not just for keeping the records up-to-date but used effectively for taking corrective measures as well as proper planning for future. Some information is, therefore, required to be collected to have an overall idea of the prevalent situation, deficiency in the system and likely requirements of the further information which could highlight deficiencies in the system on day-to-day basis and could be used for taking corrective measures has to be collected at regular intervals to monitor the services. Computerisation of such information helps at all the levels of administration to work not harder but smarter, increases the level of job satisfaction, and also to establish strong and reliable information data base necessary to facilitate the decision making and monitoring process for management.

With the advancement of information technology, Geographic Information System (GIS) could be introduced in large cities and integrated with Management Information System. Similarly, there is a need for a citizen interface to seek comments, suggestions etc., in respect of utility services.

23.1.2 Need

Information that needs to be recorded and studied includes relevant information of the department for planning process as well as specific information to know whether every one involved in SWM services is performing his duty well, adequate vehicles are given to the SWM Dept. by the workshop, the vehicles give their optimum output, the repairing and maintenance of vehicles and equipment at the workshop is properly done, the vehicles carrying the waste to the disposal site are optimally utilised, the processing plants are performing well, landfill sites are well managed etc.

The first thing each morning the chief executive should see is whether anything unusual or unsatisfactory has happened needing immediate remedial measures. A list of items is given below on which the data should be collected and kept on record for planning purposes and a few proformae are designed for monitoring the activities done by various sections of SWM department as under which may be utilised by the local bodies with suitable modifications.

23.2 GENERAL INFORMATION DATA

These general information to be collected and updated from time to time

23.2.1 Salient Features of the City/Ward

1. Area of the city
2. Population of the city
3. Decadal growth of population
4. Number of wards, their area and population
5. Ward-wise information in regard to :
    - Population density in different wards
    - No. of Households, shops and Establishments
    - Vegetable/fruit/meat/fish markets
    - No. of Slaughter Houses
    - No. of Educational Institutions
    - No. of Theatres / Meeting halls
    - No. of office complexes
    - No. of Temples - Religious centres
    - Number of Hotels & Restaurants, Marriage halls
    - Number of Hospitals & Nursing Homes
    - Number of Industries, Large / Medium / Small
    - Number of Slum pockets / their population
    - Road length/width
    - Percentage of area covered with Under-Ground Sewage system
    - Percentage of area having Surface Drains
    - Percentage of area having no Drainage Facility
    - Total Number of Public Toilets and Toilet seats
    - Number of Public Urinals
    - Number of Nuisance Spots type, size and age.

23.2.2 General Information on S.W.M.

23.2.2.1 Waste Generation

- Average quantity of waste generated per capita - per day in Kg.
- Average quantity of waste produced each day in metric tonnes(M.T.)
- Seasonal variations in daily waste generation
- Total quantity of waste produced annually during last 3 years(M.T.)
- Breakup of the quantity of wastes generated per day in Kg or M.T.
  - i. Household, shops and establishment waste
  - ii. Vegetable and food market waste
  - iii. Meat, fish and slaughter house waste
  - iv. Construction & demolition waste
  - v. Hospital waste - non infectious - general
  - vi Industrial waste - non hazardous
- Average number of carcass removed each day

23.2.2.2 Staff Position

- Number of sanitation workers deployed in the city for the collection of waste
- Number of sanitation workers deployed for the transportation of waste (loading)
- Ward wise allocation of sanitation workers
- Sweeper/ population ratio in each ward
- Sweeper/ road length ratio in each ward
- Sweeper/ supervisor ratio in each ward

23.2.2.3 Waste storage depots

- Number of sites designated / notified for temporary collection of waste (Dust bins) / dalaoh / open site / open site
- Type and size of dustbins / dalaoh / open site provided in each ward
- Ward-wise quantum of waste generated each day.

And for other information refer Chapter 12 of the Manual.

23.2.2.4 Transportation

- Number of vehicles available with the local body for the transportation of waste, their type, size and age
- Number of trips made by each vehicle in one shift.
- Number of vehicles used in :
  - First shift
  - Second shift & Third shift
- Quantity of waste transported in each shift
- Quantity of waste transported by each vehicle
- Total quantity of waste transported each day
- Percentage of waste transported each day

And for other information refer Chapter 13 of the manual.

23.2.2.5 Composition of Waste:

(i) Physical Characteristic (% by weight):

Paper

Plastic

Metal

Glass

Dust (Inert)

Organic (Decomposable)

Leather

Coconut Shells

Dry Leaves

Rubber etc.

(ii) Chemical Characteristics:

Moisture percentage (by weight)

Calorific value (K. cal/Kg)

pH Value

Organic Content

Carbon Content

Nitrogen

Phosphorus as (P_2O_5)

Potasium as K_2 O

Carbon/Nitrogen Ratio

(iii) Toxic Material Content:

Cadmium	Pesticides
Sulphur	Fertilizers
Lead	Chemicals
Mercury	Insecticides
Chromium	Paints
Copper	

And for other information refer Chapter 3 of the Manual

23.2.2.6 Waste Processing and Disposal

- Number of waste processing and disposal sites in the city
- Their distances from the centre of the city
- The area of the these sites
- The qty. of waste treated / disposed of at each site
- The expected life of each land filled site

23.2.2.7 Computerisation

Computer cell should be made available in all the Urban Local Bodies. Computerisation of all information helps all the levels to work not harder but smarter and increases the level of job satisfaction and also to establish strong in reliable information data base necessary to facilitate the decision making and monitoring process for management.

23.2.2.8 Financial Aspects

Operating Cost

a. Cost of collection / tonne / day
b. Cost of Transportation / tonne / day
c. Cost of Disposal / tonne / day
d. Allocation of revenue and capital budget for SWM vis a vis the City Corporation budget - Annual

23.3. TECHNICAL

23.3.1 Primary Collection

Primary collection is the first and prime activity in Solid Waste Management. For Planning and designing effective, sustainable and cost effective and efficient primary collection system, the following information shall be established for each Ward / Town / City. (For other information refer Chapter 10 of the Manual)

23.3.1.1 Population and Composition of Waste

- Present & future growth of population
- Waste generation per capita / day
- Quantity of waste generated per day
- Area
- Population density
- Physical Characteristic
- Chemical Characteristic & Toxic Characteristic

And for other information refer Chapter 3 of the Manual

23.3.1.2 Source of Generation

- Residential
- Commercial
- Industrial
- Hospital

- Institutional
- Water Ways - Rain Water Drain - Silts
- Construction waste

23.3.1.3 Manpower and Implements

- Man Power - Sanitation workers in local body
- Contract workers
- NGO / CBO - Voluntary agencies workers
- Implements Tools and Plants
- Primary collection vehicles
- Containerised Hand Carts
- Wheel barrow
- Storage Depots (Dust bins / Open Collection / Dalaoh)
- Welfare Measures for workers

  Uniforms, Housing , Healthcare, Loan for education , Literacy and Motivation.

23.3.1.4 Monitoring of Primary Collection Services

The following data may be collected, compiled and analysed for daily, weekly and monthly monitoring of SWM activities as per the Proforma designed as under by the individual and Section of SWM department for effective management of SWM services. Also refer Annexures 23.1(a) & 23.1(b)

I. REPORTS TO BE SENT DAILY

(a) Collection of Waste:

i. Number of sweepers required to report for duty.

ii. Number of sweepers actually reporting for duty

iii. Number of sweepers absent

iv. Areas left unattended

v. Arrangements made or proposed to be made for clearing the backlog.

(b) Inspection by Supervisors for Street Sweeping & Primary Collection:

i. Number of persons required to supervise
ii. Number of persons supervised during the day
iii. Number of cases where performance found satisfactory
iv. Number of cases where performance was not upto the mark
v. Action taken or proposed to be taken
vi. Complaints received and attended

(c) ***Inspection of Cost Recovery Services:***

Such as Hotels, Hospitals, Commercial streets and Offices

i. Number of cost recovery sites under his charge
ii. Number of sites inspected
iii. Deficiencies noticed
iv. Complaints received and attended
v. Action taken or proposed to be taken

(d) Inspection of Bulk Community Waste Storage Sites:

Number of sites in the area under his charge

i. Number of sites inspected
ii. Number of sites found well maintained
iii. Number of sites found ill maintained or needing repair or replacement
iv. Action taken
v. Number of unauthorized waste disposal sites or sites identified during field visits.
vi. Action taken

(e) Inspection of Silt Removal Sites & Building Waste Disposal Sites:

i. Number of silt removal sites inspected

ii. Number of sites found satisfactory

iii. Number of sites where silt was found lying outside the man hole or surface drain.

iv. Number of construction sites / construction waste disposal sites visited

v. No. of sites where construction waste was found disposed of unauthorisedly.

vi. Action taken

(f) Recovery of Additional Cleaning Charges:

i. Name of the ward

ii. Areas visited

iii. Additional cleaning charges recovered :

	Number	Amount (Rs)
From households		
From shops		
From offices		
From other establishments		
From road side vendors, eating points		

II. REPORT TO BE SENT MONTHLY

(a) Cost Recoveries / Penalties:

Wardwise cost recoveries made every month for a variety of services rendered. Wardwise penalties or levy of administrative charges from offenders every month.

(b) Legal Matters:

Number of cases filed in the courts each month for violation of sanitation laws. For the effective monitoring of SWM services, the information collected in various proformae should be carefully analysed and corrective measures taken promptly.

There should be route maps and duty charts with each of the supervisory staff, who should check whether work on site is going as per schedule and whether vehicles and manpower are giving their optimum output. Wireless pagers or other communication networks essential for effective communication and monitoring of services.

23.3. 2 Secondary Collection

23.3.2.1 Transfer Stations

The second and vital activity in Solid Waste Management Services is the Transfer of Waste prior to Transporation. To design and decide establishing an ideal Transfer Station either a "Delaou" or Transfer station or "sub depot" and to ensure synchronised Transporting system, the following information need to be established for every Town / City or ward.

- Location
- Area
- Capacity
- Type of Transfer System
- Mode of unloading
- Mode of loading
- Type of Vehicles - Through-In and Out
- Sources of collection - wards / streets
- Reception facility
- Quantum assessment-weigh bridge
- Period of operation
- Sanitation Impact aspect
- Operated by private / Department / Local Body / NGO
- Segregation facility - Wet / Dry
- Rain Water Drain Facility
- Compound wall & Security & Lighting & Washing
- Public Resistance

The Information Formats for all these parameters are enclosed in Annexure 23.2(a) & 23.2(b).

23.3.2.2. Transportation

Secondary collection, otherwise termed as Transportation plays a vital role in solid Waste Management services. This is mostly a mechanised System of operation. To enable designing a cost effective and efficient Secondary collection system to synchronise with the operation of primary collection and Transfer systems, following information are to be essentially established for each Ward / Town / City.

(a) Source / Storage:

- Quantity of Garbage generated
- Source of generation
- Physical and Chemical Characteristic of garbage
- Length of road
- Width of road
- Collection points (Dust bins / open collection)
- Transfer Points (Delaou / Transfer Station / Sub Depots)
- Distance between the collection points
- Distance between the Transfer points
- Quantity at collection points / Transfer points
- Pay load capacity of the vehicle

(b) Transportation of Waste:

- Number and type of vehicles and equipment required to report for duty.
- Number and type of vehicles and equipment which actually reported for duty.
- Breakdowns reported during the day and action taken.
- Number of trips made to the disposal site by each vehicle.
- Number of bins cleared during the day.
- Number and locations of bins left uncleared and

- Arrangements made or proposed to be made for clearing the backlog

(c) Quantities of Waste Transported:

- Number of vehicles deployed during the day
- Number of trips made
- Quantity of waste transported
- Number of vehicles which did not make adequate trips
- Number of vehicles which carried less garbage
- Action taken or proposed to be taken against defaulters

(d) Record of Trip Made by Transport Vehicle at the Processing and Disposal Sites:

- Serial Number
- Date
- Vehicle Number
- Name of the Driver
- Arrival time of the vehicle
- Trips made including this trip
- Waste Source and Route Number
- Weight of Waste in M. tones
- Deficiencies noticed
- Action taken

(e) Vehicle & Machinery:

(i) **Vehicles :**

- Tipper
- Non - Tipper
- Make
- Ordinary body truck
- Stainless Steel lined body

- Heavy / Light Category
- Trip Assigned - FN / AN / Night
- Quantity assigned / Trip
- Ownership
- Private
- Department
- Distance to Dumping Ground / Disposal Site

(ii) Route Schedule : (each ward / each shift):

- Starting time
- Closing time
- Distance travelled
- Duration
- No. of collection / Transfer points
- Assigned quantity
- Fuel efficiency - HMV / LMV

(iii) Machinery:

- Bull Dozer
- Loaders
- Bulk Refuse Collector
- Compactor
- Roll-on-Roll off equipment

(iv) Depots:

- Zonal Depots / ward No.
- Centralized Depot
- Role of Repairing / maintenance
- Fuel Station
- Infrastructure

- Shift of operation
- Private Sector participation - maintenance - security

(v) Manpower:

- Drivers
- Mechanics
- Cleaners
- Security
- Technical Assistance (JE / AE)
- Norms
- Private Sector (Maintenance & Security)
- Welfare measures.

(vi) Monitoring of Vehicles / Machinery:

- Performance & Utility
- Fuel Efficiency
- Cost Analysis

The input format for all these parameters are enclosed in Annexures 23.3(a) to 23.3(f)

(f) Workshop Performance : Monthly Statement:

- Number and percentage of vehicles on road
- Number and type of vehicles under repairs at Corporation's or private workshop
- Nature of breakdown
- Duration of breakdown : under one week, 1-2 weeks, 2-4 weeks and over one month.
- Reasons for delay in repairs
- Expected date of vehicle to be back on road

- Number and type of vehicles and equipment required to be given to the SWM Dept. by the workshop or through contractor.
- No and type of vehicles and equipment actually given
- Shortfall if any
- Reasons
- Alternate arrangements made
- Action taken

Computerisation of inventory daily with in and out information, balance in stock and economic order quantity would be very useful to keep track of availability and replacement of spares.

(g) Inspection of Workshop Stores:

- Whether the list of fast moving items is maintained
- Whether the list of critical items is maintained
- Whether minimum level of stock is maintained
- Items found to be out to stock
- Items found to be over stocked
- Deficiencies / irregularities noticed
- Action taken.

(h) Each Vehicle Should Maintain a Log Book Showing Information of its Daily Movement and Performance as Under :

VEHICLE LOG BOOK

Department	Date
Vehicle Number	Shift
Driver's Name :	

1. Departure from workshop
2. Return to workshop
3. Fuel taken Ltrs.
4. Kilometer reading at start of work
5. Kilometer reading at the end of work

6. Total mileage / kilometer
7. Details of trips made and locations covered
8. Inspected at point Number ______ by ______ at ______ am/pm
9. Weight recorded at weighbridge Time in / Time out

Weighbridge Operator's signature

Driver's Signature User Dept's Signature

23.3.3 Disposal

Disposal is the last and most important activity in Solid Waste Management practices. To have and effective planned operation of Disposal and to design for developing and Engineered and Scientific Disposal system, the following information need to be established.

23.3.3.1 Options

1. Recycling
2. Processing / Treatment
3. Landfilling

(a) Re-cycling:

Recycling is a waste processing technique. By recycling new useful material is produced for use, at the same time the quantity of waste for disposal is very much reduced in volume.

(b) ***Processing / Treatment:***

To plan for effective waste processing technique following information need to be established. (Also refer format in Annexure 23.4(h).

1. Physical Conversion - Refuse Derived Fuel Pellets
2. Thermal Conversion for Energy Recovery-Incineration,Pyrolysis/ Gasification.
3. Bio-Conversion for Energy Recovery-AnaerobicDigestion/Bio-Methanation.

4. Bio- Conversion for Compost production - Aerobic Composting, Vermi Composting.
5. Quantity of waste
6. Characteristic of waste - Physical and chemical
7. Extent of Landfill
8. Marketing & Demand
9. Performance Analysis Report - Success story
10. Cost Analysis
11. Training
12. Government Policy
13. Response from Private Sector

(c) Landfilling:

For Landfill identification, selection, designing and operating the following information are necessarily to be established. For landfilling refer Chapter 17.

1. Site Topography and Location and Land use
2. Ownership
3. Extent
4. Habitation
5. Public consultation
6. Access
7. Hydrology - Ground Waster level
8. Flood Control
9. Environmental Assessment
10. Nature of disposal
    (a) Open dump
    (b) Controlled dump
    (c) Engineered land fill
    (d) Sanitary landfill
11. Life expectancy - Void space (cubic metre)
12. Leachate and Methane Protection

13. Infrastructure
14. Personal and Training
15. Machinery
16. Monitoring - Operation and maintenance
17. Economic - Cost Analysis
18. Public Resistance.

Refer formats in Annexures 23.4(a) to 23.4(g) and also refer Chapter 17.8.2.1 on " Record keeping" in Chapter 17 on "MSW Landfills".

23.3.3.2. Daily/Weekly Records

(a) Inspection of Processing Sites:

i. Whether the plant was functional during the week
ii. Whether it received the garbage as prescribed regularly
iii. Whether the site is properly maintained and waste stacked properly.
iv. Quantity of Bio organic fertilizer / desired material produced
v. Quantity of production sold during the week
vi. Quantity of end product in stock
vii. Any irregularity noticed
viii. Action taken

(b) Inspection of Waste Disposal Site: (also refer Chapter 17)

i. Name of the site inspected
ii. Whether all the staff were present on duty during the week
iii. Whether the required machinery was available on site on all the days
iv. Whether the approach road and internal roads are properly made
v. Whether the weigh bridge is functional and properly used
vi. Quantity of waste received at the site on the days during the week
vii. Whether the entire waste was spread, compacted and covered on the same day.

viii. Whether communication facilities such as telephone, wireless etc. remained functional during the week.

ix. Whether shelter and drinking water facility is adequate

x. Deficiencies noticed

xi. Remedial action taken or proposed to be taken

23.4 PROJECT MONITORING

For any Project of Solid Waste Management an effective information system is necessary to monitor the progress as well as the operation and maintenance of the project, time to time.

The information format is enclosed in the Annexures 23.5(a) and 23.5(b).

23.5 PUBLIC AWARENESS AND TRAINING

23.5.1 Public Awareness

Public awareness is an important activity in Solid Waste Management to keep the system sustainable. The Information related to public awareness are necessary for creating a sustainable system.

23.5.2.Training to Ward Councilors

In the context of 74th amendment to the constitution with decentralized Local Body administration training for Ward Councilors in the area of Solid Waste Management is essential. Training for SWM staff at all levels is also essential.

23.5.3 Partnership Role for Public Awareness

1. NGO
2. CBO

23.5.4 Mode of Implementing Public Awareness Programs

1. Audio & Video program
2. IEC program
3. Child to child education
4. School education

23.5.5.Public Participation

- Total number of sweepers allotted for door to door waste collection work in each ward.
- Number of sweepers getting good response from citizens in the matter of doorstep collection.
- Number of sweepers not getting response from the public
- Percentage of public participation
- Improvement in this area over the last month.

23.6 INSTITUTIONAL ORGANISATION

The information on Institutional Organization is very much essential for Solid Waste Management for any Town / City / Local Body with responsibilities and roles, for setting up an effective administration set-up.

1. For population 1 lakh to 5 lakhs
2. For population 5 lakhs to 15 lakhs
3. For population 15 lakhs to 40 lakhs
4. For population above 40 lakhs

23.7 POLICY GUIDELINES

Information and Policy guidelines for Solid Waste Management regarding administration, enforcement, Waste processing concession, Hospital waste, Handling of legal matters are found essential for day-to-day management. (also refer Chapter 25)

1. National Policy
2. State Policy
3. Solid waste Handling Rules notification
4. Central and State PCB guidelines
5. World Health Organization guidelines

23.8 FINANCIAL AND ECONOMIC ASPECT

The information on Finance and Economical aspects are essential for Solid Waste Management for implementing various schemes of projects and also to get revenue from various cost recovery system for any Town / City / local body for its self sustenance. Also for seeking external financial assistance.

The information format is enclosed in the Annexures 23.6(a) to 23.6(c).

23.9 LEGAL ASPECTS

Information on Legal aspects are essential to enforce and maintain Environment Sanitation. The following information are to be made available in each Ward / Town / City and also to the public.

- Municipal Act
- Public Health Act
- Penalties and enforcement
- Administrative charges
- Special service charges
- Mobile Courts
- Public Interest Litigation cases.

The information format is enclosed in the Annexures 23.7(a) and 23.7(b).

23.10 COMPLAINT REDRESSAL

Information on complaint redressel on public grievance is essential to update and get a feed-back on the nature of complaint and time taken for redressing complaints and for taking positive steps to improve the services to the public.

Following are the steps for complaint redressal system to be followed :

1. Citizen Charter
2. Centralized complaint cell
3. Zonal level complaint cell

4. Ward level complaint cell
5. Norms for Redressal of complaints
6. Monitoring of complaint redressal

FORMAT **DAY/WEEK/MONTH**

Sl. No.	Date	Name of the Complainant and Address	Nature of Complaint	Details of action taken	Remarks

CHAPTER 24
LEGAL ASPECTS

24.1. INTRODUCTION

Solid waste management systems adopted in Indian cities are highly inefficient, outdated and lacking public participation. Overall public apathy is observed in the matter of handling and disposal of municipal waste. A system of throwing garbage on the streets by citizens and local bodies collecting the waste from the streets and disposing it of in the most unhygienic manner is in vogue. These systems can be corrected by taking concerted measures involving the public at large through their active participation in the process, and by the local bodies performing their duties effectively.

Solid waste management practices can never reach the desired level of efficiency until the public participates and discharges its obligation religiously. The system therefore, can only be improved by modernizing the solid waste management system by the urban local bodies and ensuring public participation through very serious motivational efforts and by providing adequate legislative support for taking punitive measures.

24.2. PRESENT SCENARIO

Local bodies in the country are governed by various laws enacted by their respective State Legislatures. Many state laws governing urban local bodies do not have adequate provision for ensuring appropriate solid waste management systems with the result outdated systems continue affecting the quality of life of the people. For improving solid waste management practices in urban areas it is necessary to incorporate suitable provisions in the state laws to ensure public participation and providing for minimum level of solid waste management service.

Local laws also need to provide for punishment on the spot to those who do not adhere to the directions given for maintaining appropriate solid waste management systems in the urban areas, giving adequate power to the local authorities to punish the offenders.

The following legal provisions may be incorporated in the respective state laws wherever they do not exist with suitable modification wherever necessary.

24.3. PROPOSED LEGAL PROVISIONS

24.3.1 Prohibition Against Littering the Streets, Deposition of Solid Waste on the Streets, Open Defecation, etc.

No person shall litter public streets or public places or deposit or cause or permit to be deposited or thrown upon or along any public street, public place, land belonging to the local body, State or Central Government or any unoccupied land or on the bank of a water-body any solid waste except in the receptacles specified in 2, 6 and 8 above or resort to open defecation.

24.3.2 Duty of Occupiers of Premises to Store Solid Waste at Source of Generation

It shall be incumbent on the occupiers of all premises to keep two receptacles, one for the storage of food/organic/bio-degradable waste and another for recyclable and other types of solid wastes generated at the said premises. The domestic hazardous waste, as may be notified by the local body, shall also be kept separately in a suitable container as and when such waste is generated.

24.3.3 Duty of Occupier not to Mix Recyclable /Non-Bio-degradable Waste and Domestic Hazardous Waste with Food Waste etc.

It shall be incumbent on the occupier of any premises to ensure that the recyclable waste as well as domestic hazardous waste generated at the said premises does not get mixed up with the food/bio-degradable waste and stored separately.

24.3.4 Duty of Societies/ Associations/ Management of Commercial Complexes to Clean their Premises and to Provide Community Bins

It shall be incumbent on the management of Co-operative Societies, Associations of residents, multistoried buildings, commercial Complexes, Institutional buildings, markets and the like to arrange for daily cleaning of their internal streets, common spaces, etc., and provide community bin/bins of appropriate size as may be prescribed by urban local body, for the temporary storage of food/biodegradable waste duly kept segregated by the members of the society/association for facilitating primary collection of food/biodegradable waste from one point by the municipal authorities. A separate community bin may similarly be provided for the storage of recyclable waste where door to door collection of recyclable waste is not practiced.

24.3.5 Community Bins to be Kept in Good Condition

Community bins as stated in 24.3.4 above shall at all times be kept in good condition, regularly maintained and shall be provided in such number and at such places as may be considered adequate and appropriate to contain the waste produced by the citizens supposed to be served by the community bins.

24.3.6 Duty of Occupiers to Deposit Solid Waste in Community Bins

It shall be incumbent on occupiers of all premises for whom community bins have been provided as per 24.3.4 above that all segregated domestic waste, trade waste, institutional waste from their respective premises to be deposited in the appropriate community bins.

24.3.7 Duty of Local Body to Provide and Maintain "Waste Storage Depots"

It shall be incumbent on all Municipal Corporations and Municipalities in the State to: -

(i) Provide and hygienically maintain adequate Waste Storage Depots in the city and place large mobile receptacles at such places for the temporary storage of waste collected from households, shops and establishments as well as from streets and public spaces until the waste is transported to processing and disposal sites.

(ii) Make adequate provision for closed containers in various parts of the city for the deposition by citizens of domestic hazardous/toxic waste material adhering to the provisions of hazardous waste rules of Government of India.

24.3.8 Duty of Occupier of Households/Shops/Establishment to Hand Over the Recyclable Material/Non-Bio-degradable Waste to the Waste Collectors/ Waste Purchasers/Recyclers

It shall be incumbent on households / shops / establishments to hand over their segregated recyclable waste / non-bio-degradable waste to the collectors, waste purchaser or recyclers as may be convenient or as may be notified by the local body from time to time. Such waste shall not be disposed off on the streets or in municipal bins or open spaces along with the organic/food/bio-degradable waste.

24.3.9 Duty of Occupier of Households, Shops and Establishments to Deposit Domestic Hazardous/Toxic Waste in Special Bins Provided by the Local Body

It shall be incumbent on households, shops and establishments to deposit domestic hazardous waste/toxic material in containers provided by the urban local body as per 24.3.7 (ii) above.

24.3.10 Duty of Local Bodies to Collect Waste from Community Bins and to Deposit it at Waste Storage Depots for Onward Transport

It shall be incumbent for local bodies to remove all solid waste deposited in community bins on a daily basis and transfer it to the Waste Storage depots/containers identified in the city and arrange for its expeditious transport to processing or disposal sites.

24.3.11 Duty of Local Bodies to Clean All Public Streets, Open Public Spaces and Slum Areas

It shall be incumbent on local bodies to arrange for cleaning of all public streets having habitation on both or either side, and all slums on all days of the year including Sundays and public holidays.

24.3.12 Duty of Local Body to Transport the Waste Stored at the Waste Storage Depots Regularly

It shall be incumbent for the local bodies to arrange for the transportation of waste stored at waste storage depots before the waste storage containers start overflowing and daily from places where closed containers are not placed.

24.3.13 Duty of Local Body to Arrange for Processing of Food/Biodegradable Waste through Appropriate Technology and Disposal of Rejects

It shall be incumbent for the local bodies to arrange for the processing of food/organic/bio-degradable wastes produced in the city and dispose of the rejects and non-biodegradable waste in an environmentally acceptable manner.

24.3.14 Prohibition Against Deposition of Building Rubbish

No person shall deposit or cause or permit to be deposited any building rubbish in or along any street, public place or open land except at a place designated for the purpose or in conformity with conditions laid down by the municipal corporation / municipality.

24.3.15 Prohibition on Disposal of Carcasses, etc.

No person shall deposit or otherwise dispose of the carcass or parts of any dead animal at a place not provided or appointed for this purpose.

24.3.16 Punishment for Littering on Streets and Depositing or throwing any Solid Waste in Contravention of the Provisions of this Act

Whosoever litters the street /or public places or deposits or throws or causes or permits to be deposited or thrown any solid waste or construction debris at any place in contravention of the provisions of this Act permits the flow of any filthy matters from his premises shall be punished on the spot with a fine not less than Rs.50/- as may be prescribed under the rules framed by the State Govt. from time to time. Such spot fines may be collected by officers authorized by the Municipal Corporation/Municipality, not below the rank of sanitary inspector. The amount of fine imposed shall be recoverable as arrears of property taxes. The amount of fine shall be kept higher for repeat offences.

The powers to levy such penalty should also be delegated to railway authorities, cantonment authorities, notified areas, which are outside the purview of municipal corporations or municipalities in various cities so that the areas under their control can also remain neat and clean.

Other points for Consideration:

(i) Provision of Uniforms and Protective Equipment:

Local body to provide uniforms and other personnel protective equipment to the sanitation workers subject to their wearing/using them. It should not become a routine to provide uniforms and protective equipment with no insistence to use them. Local bodies should seriously consider providing such facilities and ensure that they are properly used to protect the health of the sanitation workers.

(ii) Punishment for Open Defecation and Urination on the Streets:

In the cities where adequate public toilets and urinals are provided or in the areas where such usable facilities are created by the local bodies, provisions of punishments for open defecation and urination on the streets may be considered in such areas.

24.4. SOME EXAMPLES OF ENFORCEMENT WHICH HAVE GIVEN SALUTARY EFFECT

Surat Municipal Corporation, which had a serious problem of public apathy towards handling and management of waste, introduced a system of levy of administrative charges from those who litter the streets or dispose of the waste on the streets after the street cleaning was over. The administrative charges ranging from Rs.100 to Rs.50000 and were recovered on the spot from the defaulter. This was not levied as a penalty but as a charge for cleaning the street again. This brought about a sea change in the behavior of the people. Within first three months of the drive, more than a crore rupees were recovered by way of administrative charges and city got disciplined through these enforcement measures. People formed a habit of keeping their own bins and deposit the waste into the municipal system only. Once the dirtiest city of India got converted into one of the cleanest cities of the country with active public participation. The cities of Ahmedabad, Mumbai and few others have followed suit and recovered a few million rupees by way of administrative charges and have improved the public behavior substantially. An extract of the resolution passed by the Ahemedabad Municipal Corporation for levying administrative charges vide their resolution No.899 dated 3rd October, 1997 is reproduced in the Box in the next page. Efforts of motivation coupled with sanctions only can bring about the desired results. The amendment of local laws as proposed above is, therefore, necessary.

An example of Resolution Passed by Ahmedabad Municipal Corporation for Levying Administrative Charges

Extract of Standing Committee Resolution No.899 dated 03/10/1997.

For the maintenance of health and sanitation in the city, Municipal Corporation has made an arrangement for the collection of waste from the city on day to day basis with the help of sweepers. Now, with a view to ensure that the households, shops and industrial establishments do not throw solid waste anywhere in the city and the city's health is not adversely affected, it is hereby resolved that the administrative charges should be recovered from the defaulters as under: -

	Description of the Establishment	Minimum administrative charge to be levied.	Maximum administrative charge to be levied
1.	Households	Rs.50/-	Rs.250/-
2.	Commercial Establishments	Rs.150/-	Rs.1250/-
3.	Small scale Industries	Rs.500/-	Rs.2500/-
4.	Other Industries	Rs.1000/-	Rs.5000/-

CHAPTER 25
POLICY GUIDELINES

25.1 INTRODUCTION

As per the Constitution of India, Solid Waste Management is a state subject and it is the primary responsibility of state governments to ensure that appropriate solid waste management practices are introduced in all the cities and towns in the state. The role of Government of India is broadly to formulate policy guidelines and provide technical assistance to the states/cities whenever needed. It also assists the state governments and local bodies in human resource development and acts as an intermediary in mobilizing external assistance for implementation of solid waste management projects.

Though SWM is a State subject, it is basically a municipal function and as such urban local bodies are directly responsible for performing this important activity. The 74th amendment of the constitution also envisages the urban local bodies to shoulder this responsibility. The urban local bodies in the country are, therefore, responsible and required to plan, design, operate, and maintain the solid waste management system in their respective cities/towns.

Though solid waste management is an obligatory function of the urban local bodies, this service has been poorly performed by most of them resulting in problems of public health, sanitation, and environmental degradation. With rapid pace of urbanization, the situation is becoming more and more critical day-by-day. Infrastructure development is not in a position to keep pace with population growth owing to poor financial health of most of the urban local bodies. Lack of financial resources, institutional weakness, improper choice of technology, lack of public participation in solid waste management, non-involvement of private sector, etc., have made the service far from satisfactory. There is, therefore, a need to handle this problem in a concerted manner and adopt strategies to tackle all aspects of waste management scientifically involving private sector wherever necessary and possible. A policy framework is, therefore, necessary to guide and support the urban local bodies in the country for managing the solid waste scientifically and cost effectively.

25.2 POLICY FRAME WORK

The State Governments should frame appropriate policies to guide the local bodies and take a lead role in activating the local bodies to perform their obligatory duties effectively. The state should also support the local bodies through legislative measures to enable the local bodies to perform better.

25.3 ISSUES

The following issues need to be addressed during policy formulations:

(i) Effective public participation in segregation of recyclable waste and storage of waste at source.

(ii) Public participation in primary collection of waste.

(iii) Sweeping of streets and primary collection of waste on all the days of the year irrespective of Sundays and public holidays.

(iv) Provision of closed body mobile waste storage depots and abolition of open waste storage sites.

(v) Safe and separate storage as well as doorstep collection of biomedical waste, hotel and restaurant waste yard waste, etc., on full cost recovery basis.

(vi) Avoid the need of multiple handling of waste through the adoption of principal of "handle waste once only" in the matter of collection, transportation, and disposal of waste.

(vii) Transportation of waste on day to day basis in closed body vehicles.

(viii) Processing of waste for generating compost, power, and other useful products.

(ix) Disposal of waste in an environmentally acceptable manner through establishment of sanitary landfill sites.

(x) Grant of land for processing and disposal of waste.

(xi) Institutional strengthening and human resources development.

(xii) Improving the financial health of the local urban bodies.

(xiii) Introducing element of cost recovery.

(xiv) Encouraging private sector participation in waste management.

(xv) Welfare of the staff engaged in solid waste management services.

(xvi) Creation of public grievances rederessal mechanism.

(xvii) Provision for enforcement of sanitation laws and rules.

25.4 The following measures may be taken by the Central Government, State Governments and urban local bodies in the country to address the above issues effectively.

25.4.1 The Central Government

The Central Government may:

- Prescribe minimum standards to be maintained by the urban local bodies while providing SWM services under the E.P. Act 1986.
- Periodically update the technical manual on solid waste management for the benefit of local bodies and other agencies engaged in solid waste management.
- May arrange national workshops on solid waste management and exposure visits to foreign countries and within the country for imparting knowledge and training to the officials handling solid waste management and decision-makers.
- May conduct nationwide awareness campaign to make the cities clean using "Door Darshan" and other private channels for widespread communication taking help of experts in communication.
- Provide fiscal concessions such as exemption of central excise and custom duties in purchase of special type of vehicles and equipment necessary for solid waste management.
- Promote joint ventures in setting up industry for manufacture of solid waste management equipment and vehicles within the country.
- Allow the urban local bodies to raise tax-free municipal bonds without any upper ceiling.
- Provide financial assistance for setting up compost plants and other waste processing units.
- Set up pilot plants for waste processing and disposal for the benefit of all the urban local bodies of the country.
- Extend technical guidance for implementing solid waste management system.
- Mobilize financial assistance from external sources and bilateral agencies to the urban local bodies through the state governments.

25.4.2 The State Governments

The State Governments may take the following measures:

25.4.2.1 Provide Legal Frame Work

States may make suitable legislative changes in the local laws in terms of the recommendations made in Chapter 24 of the manual. This will facilitate the enforcement of the directions that may be given by the urban local bodies from time to time to the citizens for managing their waste as prescribed and would also compel the local bodies to perform by providing adequate services.

25.4.2.2 Promote Financial Health of the Urban Local Bodies to Meet Obligatory Duties

(i) Minimum Tax to be Levied:

Merely giving power to local bodies to impose taxes have not yielded satisfactory results. Several local bodies are shy of imposing adequate taxes resulting in inadequacy of services in urban areas. The State Governments may, therefore, prescribe a minimum amount of property tax per square metre of property, the local body shall impose or levy from the property holder or take some percentage of the value of property or rent derived as property tax, which may generate adequate income to the ULB to meet their constitutional obligations. ULBs may also be allowed/ motivated to generate non-tax revenues to augment their financial resources. The ULBs are also required to be directed not to spend their funds on non-essential activities till they adequately meet their demand on obligatory duties.

(ii) Extend Need Based Financial Assistance for Capital Expenditure:

Government may assess the need of the ULBs, their capability, their compliance to government directions to raise revenues and then extend financial support to them for procurement of vehicles and equipment to improve solid waste management practices.

(iii) Linking of Incentives with Performances:

Government may link fiscal incentives in the form of grants / loans / subsidies to the ULBs with their performance in the financial sector and keep on motivating them to avail of the incentives.

iv) Facility of Long Term Loans:

Government loans may be extended to ULBs for modernization of solid waste management practices on a long-term basis to enable them to repay the loans easily.

Government may also provide technical assistance to local bodies for preparing project proposals for availing of loans from World Bank, ADB and other national and international financial institutions and give necessary guarantees/ sanctions for availing of such loan facilities.

25.4.2.3 Grant of Land for Treatment Facility and Disposal of Waste

In the cities where local bodies do not have adequate land suitable for setting up facilities for the treatment and disposal of waste, state governments may, as a policy grant to the ULBs, adequate government waste land suitable for the treatment and disposal of waste keeping in view the need of ULB of at least 25 to 30 years. Such lands may be given to the urban local bodies free or on a token lease rent for a long term of not less than 30 years. The land for the disposal of waste could also be given to the urban local bodies for a period till the land so given is reclaimed through sanitary land filling and government may take back the land, after the same is appropriately reclaimed. This will serve the purpose of the local body as well as of the state governments.

Special organized system (cell) may be created in the State Governments to access the needs of the local bodies and give fast track clearance for the allotment of land for the above purposes.

25.4.2.4 Identification of Suitable Land for Treatment and Disposal of Municipal Solid Waste in City's Development Master Plan

While preparing the development master plan of the cities, the State Govts may ensure earmarking of appropriate land for treatment and disposal of municipal solid waste keeping in view long term requirement of the cities

25.4.2.5 Permit Allotment of Land to Private Sector for Setting up Treatment Facilities and Landfill Sites for Waste Disposal

The grant of government land to ULB should have an enabling provision allowing urban local bodies to give part of that land to private entrepreneur for setting up treatment/disposal facility for the urban local body. It should also be permitted to give such lands to private entrepreneurs on a token lease rent for a period of 15 to 30 years subject to conditions that maybe prescribed by the urban local bodies not inconsistent with the terms prescribed by state government while granting the same land to ULB. It would be desirable to give land on appropriate token lease rent of per year for a long term as indicated above to attract private entrepreneurs to invest in waste management sector.

25.4.2.6 Payment of Tipping Fees

The private sector participation may be encouraged in such away that it does not affect the interest of the existing labour, it does not violate the existing provisions of the law, does not exploit the private labour and yet reduce the burden of urban local body of new establishment. This will substantially help in improving the quality of service of the urban local bodies, effect economy in expenditure and would also give a scope to private sector in waste management market.

25.4.2.7 Promote Recycling Industry

The State Governments may declare a policy to promote industries for recycling of municipal solid waste by giving priority in allotment of land/sheds/power/water, etc. and give necessary clearances / NOCs expeditiously. Government may also direct the government organizations and local bodies to purchase recycled products to encourage such industries.

25.4.2.8 Provide Tax Benefits

The State Government may consider granting local tax benefits / exemptions to solid waste recycling industries / treatment plants for at least 5 years.

25.4.2.9 Promote Use of Compost

State Governments through their agriculture departments and outreach net work, may propagate use of compost made from municipal solid waste on the farm land after being satisfied that the product meets the necessary standards for the application on the farm- lands. Government may also consider subsidizing the sale of such compost.

25.4.2.10 Promote Energy Recovery, Power Generation, etc., from MSW

Government may support proven technologies for power generation from municipal solid waste by grant of land on token rents, license for power generation and making power purchase agreements at the rates that may be affordable to power producers keeping in view the social benefits derived from such activity

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(Regulation & Abolition) Act 1970 and prepare standard concession agreements to guide the urban local bodies.

25.4.2.12 Develop IEC Material

The state governments may develop appropriate information, education and communication material (IEC) according to the local needs and take up statewide awareness campaign and help the urban local bodies to build public awareness in their cities and towns and promote the principle of "Reduce, Reuse And Recycle" municipal waste.

25.4.3 The Urban Local Bodies

The urban local bodies on their part may frame their policies as under: -

25.4.3.1 Provision of Daily Service

Local bodies, as a policy, should provide SWM services such as sweeping of streets, primary collection of waste and disposal of waste on all the days of the year including Sundays and public holidays. As the waste is generated on all the days of the year, its collection can not be deferred on Sundays or public holidays in absence of adequate arrangements to clear the back log on the next working day. For the maintenance of health and sanitation in the urban areas, it is necessary that this service be provided round the year.

25.4.3.2 Segregation and Storage of Waste at Source

The local body should formulate and notify a policy that no waste shall be disposed of on the streets, open spaces, drains, water bodies, etc., and instead the recyclable and other biodegradable shall be stored separately at the source of waste generation and shall be handed over to the waste collectors as per the arrangements that may be notified by the local body from time to time.

25.4.3.3 Abolish Open Waste Storage Depots and Other Inefficient Waste Storage Devices

The local bodies may immediate phase out abolition of all open waste storage sites, cement, concrete, pipes, masonry bins,

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al services to the commercial and industrial units towards the collection, transportation and disposal of solid waste.

25.4.3.5 Levy of Sanitation Tax to Meet & Cost of SWM Services

The urban local body should impose adequate sanitation tax to cover the cost of SWM services. Whereas efforts should be made to effect cost recovery from the beneficiaries who get doorstep service, the shortfall of funds should be made good from general sanitation tax, which should be adequately imposed, as a matter of policy by the urban local bodies.

25.4.3.6 Public Private Partnership in SWM Services

There is a need to promote a healthy competition in the SWM service being provided by the urban local bodies and the private sector. The manpower cost is going up steeply in the local bodies and efficiency levels are coming down. There is, therefore, a need to induct private sector to provide SWM services in un-served and under-served areas in a cost effective and efficient manner. This will reduce the costs and promote an element of healthy competition between public and private sector.

25.4.3.7 Private Sector Participation

The ULBs may promote private sector participation on the lines indicated in Chapter 20 of this Manual. They may as a policy decide to set up treatment facilities and doorstep collection service with the private sector participation on suitable terms and conditions for which standard concession agreements/formats may be drawn up with legal assistance to ensure protection of ULB interest.

25.4.3.8 Provision of SWM Services in Slums

The local bodies should frame a policy of providing community bins for the storage of waste or daily door-to-door collection service in the slums to ensure sanitary conditions in the slums irrespective their legal or illegal status iY

A . B C : \ M y D o c u m e n t s \ M a n u a l o n M S W M \ C h a p t e r X X V - P o l i c y G u i d e l i n e s . d o c O P E Y A . ? C : \ D O S \ A u t o R e c o v e r y

s a v e o f C h a p t e r X X V -

25.4.3.9 O P E Y A . ? C : \ D O S \ A u t o R e c o v e r y

f Chapter XXV - Policy Guidelines.asd OPEY A.?C:\DOS\AutoRecovery save of Chap eration and maintenance of SWM services. Appropriate percentage of the budget of the local body should be earmarked for efficient management of SWM services.

25.4.3.10 Identification and Allotment of Suitable Lands for Treatment and Waste Disposal

The local body should assess the need of land for treatment and disposal of waste disposal for the next 25 to 30 years and identify suitable municipal land for allotment to the solid waste management department. If suitable land is not available the same should be acquired or obtained from the state government expeditiously.

25.4.3.11 Human Resources Development

The local body as a policy should provide adequate training to the staff engaged in solid waste management services and arrange for short term and refresher courses for updating the knowledge of the supervisory staff to maintain the high standards of service. All components of SWM services, including the workshop, should be under one umbrella to ensure effective supervision and control.

25.4.3.12 Public Grievances Redressal Mechanism

The local bodies should draw up a citizens charter and create a system to register public grievances in all the wards and set up a mechanism for expeditious redressal of grievances through decentralized municipal administration.

25.4.3.13 Enforcement

While all efforts may be made to build awareness among the community for public participation in solid waste management services in the urban areas, a mechanism for enforcement should be simultaneously created to discipline the citizens who do not adhere to the directions of the urban local bodies. Those who litter the streets or create unhygienic conditions, in spite of the facilities provided by the urban local bodies, should be punished through levy of fines, administrative charges, etc. Mobile sanitation courts could be established in metropolitan cities to have a salutary effect.

25.4.3.14 Welfare of the Staff

The staff engaged in handling of solid waste need to be given adequate protection and health care facilities. The local body, as a policy, should provide adequate protective clothing and health check up from time to time to the staff to ensure that their health is not adversely affected on account of their handling of solid waste. Free medical services should be made available to those whose health is affected on account of handling solid waste

25.5 POLICY ORDERS ISSUED BY SOME STATES

Some of the policy orders issued by the state governments to promote waste to energy projects are given in Annexure 25.1 for the information of other state governments and ULBs.

State governments may consider issuing suitable policy guidelines to promote treatment and disposal or municipal solid waste by various processes through private sector participation.

25.6 Ministry of Environment & Forests, Government of India have issued draft notification for Municipal Waste (Management & Handling) Rules, 1999 vide notification No.SO 783(E) dated 27th September, 1999 covering various aspects of SWM (copy at Annexure 1.1). These rules would be applicable throughout the country as and when finalised and state policies on SWM have to be shaped accordingly.

CHAPTER 26

PREPARATION OF A MUNICIPAL SOLID WASTE MANAGEMENT PLAN

26.1 THE PLANNING PROCESS: DEFINITION

Planning is the conscious process for meeting future requirement and objectives with full consideration of any likely contingencies. The plan should guide intended actions specifying the time and priorities for accomplishing this intended action. The planning process is a systematic method of:

(1) recognizing the problems that exist;

(2) collecting and analysing data about these problems;

(3) assessing the situation in light of the analysed data;

(4) suggesting actions, the accomplishment of which will serve to change the situation or correct the problem;

(5) evolve suitable strategy for implementation with respect to time frame; and

(6) evaluation of the actions taken in light of their success or failure in achieving objectives and modification of the plan, if need be, to meet changing conditions.

A city plan for solid waste management, therefore, should be a written document outlining the activities that the civic body intends to undertake during the life-span of the plan, coupled with a set of directives for achieving those objectives in a given time frame.

26.2 DESIGN PERIOD

Municipal Solid Waste Management involves activities associated with generation, storage, collection, transfer & transport, processing, recovery and disposal of solid waste, which is environmentally compatible adopting principles of economy, aesthetics, energy and conservation. It encompasses planning, organisation, administration, financial, legal and engineering aspects involving inter-disciplinary relationships.

While preparing a municipal solid waste management plan, the following design period (time-frame) involving all such activities as stated above would have to be decided depending upon the necessity of solid waste management plan:

(i)	Short-term plan	2-5 years
(ii)	Medium-term plan	5-15 years
(iii)	Long-term plan	15-25 years

The planning process involves close collaboration with other planning agencies at Local, State and National levels to ensure better coordination in allocation of priorities and resources. The collection, transportation, processing and disposal aspects, the facilities, augmentation and replacement of the equipment and sites, allocation of priorities and resources should invariably be decided keeping in view the design period of municipal solid waste management plan.

26.3 POPULATION FORECAST

The design population will have to be estimated with due regard to all the factors governing the future growth and development of the project area in the industrial, commercial, educational, social and administrative spheres. Special factors causing sudden emigration or influx of population should also be foreseen to the extent possible.

A judgement based on these factors would help in selecting the most suitable method of deriving the probable trend of the population growth in the area or areas of the project from the mathematical methods, graphically interpreted where necessary as indicated at ***Annexure 26.1***. Worked out examples for estimation of the future population by some of the methods are given in ***Annexure 26.2***.

26.4 BASIC PLANNING MODEL

The procedure for developing a city plan for Solid Waste Management(SWM) can be explained by structuring various steps normally considered for the formulation of a plan and can be shown in a simple **9-step model** (Figure 26.1). The planning process is not static, as it may appear on paper, but dynamic and continuous. Various steps in the planning process should also be considered as they may be occurring simultaneously although in preparing the written plan, some civic bodies may prefer to consider each phase in sequence. Each step could, in fact, serve as a separate chapter or section of a civic body plan. A planning model should provide feedback into the system from various planning process events as these occur (Figure 26.1). The model itself has built-in controls to allow for correction of errors discovered through feedback relationships. Developments outside the planning process also cause corrections or revisions. Social, legal, and environmental changes can affect the plan and need to be considered.

26.4.1 Initial Planning

Awareness or recognition of a situation is the first step in the planning process and is the catalyst that results in the second action: data collection and analysis. The data and their analysis will provide the basic facts without which planning is impossible. Analysis of data will also point out problem areas and situations requiring solution in the plan. Environmental and Health Impact Assessment (EHIA) study should also be carried out simultaneously (Figure 26.1, steps 1 and 3).

26.4.2 Problem Redefinition

As indicated by analysis of the data, the next step is to redefine the problem and assess the situations and conditions that will likely to emerge in the future. This requires forecasting (Figure 26.1, step 4).

26.4.3 Objectives and Consideration of Alternative Actions

Having known enough about the problem, specific objectives may be set and strategy for achieving these objectives may be suggested (Figure 26.1, steps 4 and 5), stating clearly what needs to changed or required to correct the problems. Where should modifications be made? Several alternatives might be available to achieve the set objectives.

26.4.4 Emerging Alternatives and Decisions

Which alternative or alternatives should the planner selects to accomplish the objectives set forth to solve solid waste management problems of the city? The answer to this question will help establish the programme priorities. These decisions are subject to all sorts of influences that must be considered when developing the solid waste management plan (Figure 26.1, steps 6 and 7). Such influences include political, administrative, legal, social, and financial factors, and available technology. Basic among these are technical, administrative and political influences. Because of the technical nature of the decisions, a specialized inter-disciplinary staff, the one that has been developing the plan to this point, should continue to play a role in supplying information and expert evaluation of

BASIC PLANNING MODEL

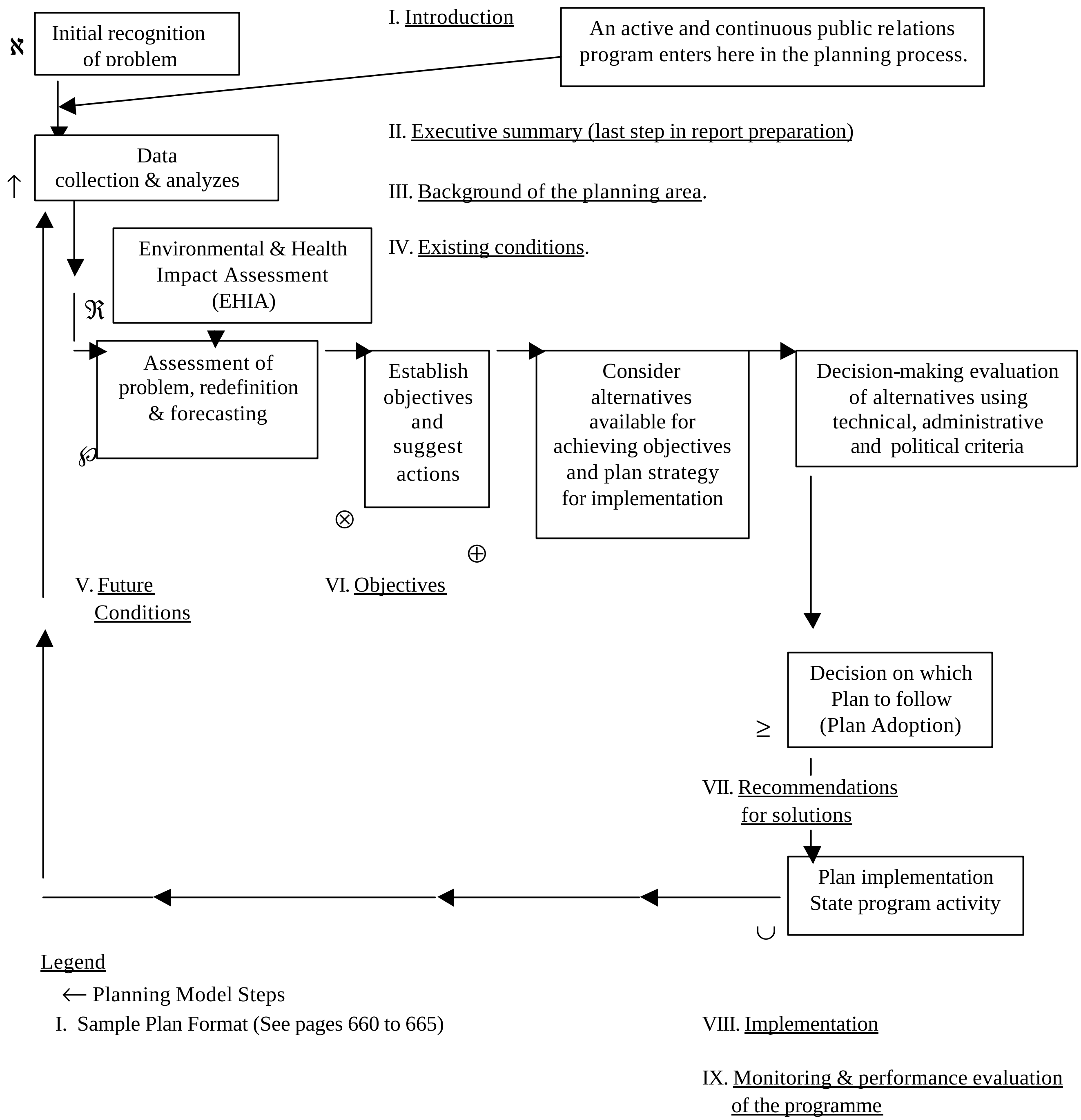

FIGURE 26.1: (1) In the planning process is awareness that a problem exists and needs to be solved. (2) To collect and analyze data relating to the problem. Such analysis makes possible to assess the situation and redefine of the problem and a forecasting of future situation. (3) The significance of environmental and health impact assessment is aimed at improving the information support for proper management of municipal solid waste. (4) Problem definition for both the present and future situation. (5) Helps to suggest objectives that if achieved would solve the problems. (6) Two or more alternatives might be available for solving the problem and achieving objectives. (7) The feasible alternative or alternatives are selected by considering technical, political, social and other factors. (8) Once this decision has been made a plan for solution of the problems can be adopted. (9) Actual action for carrying out the plan follows. Effectiveness of

the plan is measured during its implementation. This data is fed back into the continuing planning process to guide plan modifications, if needed.

alternative solutions and implementing the plan. Evaluation of existing plans is an important part of this step. Solid waste management plans should be compatible with existing plans, assuming such plans take solid waste needs into account. Therefore, decision-making for the city solid waste management plan will be based to some extent upon political and administrative exigencies, specialized technical analysis, and existing plans.

Those alternative solutions, which appear feasible on the basis of such consideration, should be submitted to the appointed and elected public representatives and the public itself for review and possible adoption, but not without adequate preparation for such a step. This means a program of education of public representatives and the public is a vital and integral part of the entire planning process. **The agency conducting the planning should have initiated an information and education program early in the plan formulation stages, and the public information plan should continue through implementation of the entire plan. Print and electronic media can play vital role in creating awareness and educating the public. News releases, films, articles, and speakers, for example, can help develop public awareness and aid in approval of solid waste management plans and programs.**

26.4.5 Plan Establishment

Once the decision-making stage has been completed, decisions should be translated into the recommendations and priorities that form the core of the plan (Figure 26.1, step 8). Although, at this point, a city plan for solid waste management has emerged, the planning process has not been completed. Planning will be continuous and proceed concurrently with implementation of previously planned proposals (Figure 26.1, step 9). Original plans will need re-evaluation and modification to accommodate changing situations. Earlier forecasts will require revision. This evaluation and modification will provide new information and along with the results of implementing the plan will be fed back into the planning process, as indicated in the model.

26.5 COORDINATION

The essence of planning is coordination. Planning requires resolution of conflicting interests, allocation of available funds and other resources, inter-governmental and inter-departmental cooperation, and establishment of priorities. From the standpoint of the direction and overall needs of National Government, a solid waste management plan is one among several functional plans, such as those dealing with highways, natural resources, education, health, etc. City solid waste management plans, therefore, should relate to, and not conflict with, other plans of the city. It is essential that the city solid waste management planning be included in the overall plan of the jurisdiction that will ultimately implement it. In this way the solid waste management agency will be able to compete effectively for funds, personnel, and other resources and facilities.

26.6 PLAN OUTLINE

The basic planning model (Figure 26.1) can be translated into an outline for reporting the established plan. Such a format communicates the logic inherent in the planning procedure. Planning initiative and innovation are desirable, however, and each civic body is expected to formulate its own systematic outline and report, taking into account its particular needs as indicated in the following sample format for the preparation of the Municipal Solid Waste Management Plan.

SAMPLE FORMAT FOR PREPARING MUNICIPAL SOLID WASTE MANAGEMENT PLAN

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Corresponding steps in the model	Elements of the Report
1	**Foreword or Preface (or both)**
	Table of Contents
	Section I **<u>Introduction</u>** Purposes of the plan.
	Section II **<u>Executive Summary</u>** (Note: This section should be written last and may come at the beginning of the report)
2	**Section III** **<u>Background of the Planning Area</u>**

1. Jurisdictions

a. National
b. State
c. City/Town
(Civic Authorities)
d. Location Map
e. Population (size and densities)
f. Housing (types and locations)
g. Land uses (residential, commercial, industrial, agricultural, extractive, recreational, and other relevant land uses)
h. Transportation corridors

2. Physical Conditions

a. Environmental conditions
b. Geology and soils
c. Climatology
d. Drainage basins

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in the model

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e. Geographical Information System (GIS) (with particular reference of metro & mega cities)

f. Financial status

   i. Tax base (assessed valuations)

   ii. Tax rates

   iii. Public finance practices

   iv. Economic base

   v. Others

g. Status of legislation

2 & 3 **Section IV** **<u>Existing SWM Conditions</u>**

1. Arrange data according to specific needs of the planning agency. As far as possible all the information related to municipal solid waste management have to be collected.

2. Describe and analyze all existing conditions affecting management of municipal wastes.

a. Storage, segregation and primary collection of waste

b. Quantities of wastes generated, with generation rates, collected and disposed of

c. Transportation and disposal practices

d. General management practices (e.g., utilization of manpower and equipment)

e. Public awareness and knowledge about solid waste problems and willingness to pay for better services

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Corresponding steps in the model **Elements of the Report**

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f. Expenditures for solid waste management

3. Environmental and Health Impact study be carried out considering the potential adverse effects of solid waste management activities in formulation of Municipal Solid Waste Management Plan.

4 **Section V** **<u>Future Conditions and Problem Definition</u>**

1. Relevancy for the future (from the analysis of the data of existing conditions accumulated in sections III and IV, determine which conditions will have a bearing on the future).

2. Future problems defined

   a. Types
   b. Locations
   c. Extent
   d. Persistence
   e. Others

3. All existing conditions and problems bearing upon the future should be forecasted at this stage.

5, 6 & 7 **Section VI** **<u>Objectives</u>**

Objectives should be clearly stated and based upon need to solve problems defined earlier. Civic authority might specify any of the following objectives to solve its solid wastes problems:

1. Acceptable methods for storage, segregation of recyclable waste

2. Acceptable methods for primary collection of wastes
3. Acceptable methods for bulk storage of waste at waste storage depots
4. Acceptable methods of transportation of waste

5. Acceptable waste processing practices
6. Acceptable methods of waste disposal
7. Development of solid waste management organizational structure
8. Development of better trained solid waste management personnel (operating and management levels)
9. Better informed public regarding solid waste problems and service requirements
10. Provision of sufficient financial support for solid waste management
11. Others

8 & 9 **Section VII** **Recommendations for Solution (The Plan)**

1. This section should specify what the civic authority intends to accomplish in order to solve its solid waste management problems. It should include designation of the following:

a. System improvement
b. Timing and priorities of intended action (consider short and long-term objectives)

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Corresponding steps in the model	Elements of the Report

c. Who should act (i.e. agency, department)
d. Estimated costs
e. Problems that will be solved
f. Others

2. It is suggested that the following aspects be considered in intended action plan. Proposals for this action should be accompanied by procedures for accomplishment and a schedule of initiation of this action.

a. Establishment of solid waste management operating departments and identifying its jurisdictions

b. Recruitment, selection and hiring of solid waste management operating personnel
c. Human resources development programme
d. Technical assistance to operating units
e. Provisions for inspection and enforcement
f. Licensing of facilities
g. Framing legislation, amendments to rules and regulations
h. Development of budgeting procedures, financing, cost-effectiveness, special charge features and other operating management features
i. Public information, education and communication programme/system
j. Others

===

Corresponding steps in the model	Elements of the Report

Section VIII **Implementation (occurs outside the plan document but is guided by it)**

Appendices

This section of the report should include supporting materials and information used to develop the analyses, objectives, and plan. Content of this section might include:

a. Charts
b. Additional tables
c. References
d. Legislation and regulations
e. Definition of terms
f. Methodologies of research and analyses
g. Others

Section IX **Monitoring and Performance Evaluation of the Programme**

This section of the report should include monitoring of various activities of municipal solid waste management and also evaluation of the performance of all the related activities with reference to the objectives/targets envisaged, once the programme is implemented.

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The text of the Municipal Solid Waste Management Plan for a city should explain in detail all the above elements that contained in the plan report conforming to the above outline.