A BLUEPRINT FOR SUSTAINABLE SOLID WASTE MANAGEMENT IN URBAN AREAS : CASE STUDY HARDWAR

A DISSERTATION

Submitted in partial fulfilment of the requirements for the award of the degree
of
MASTER OF URBAN AND RURAL PLANNING

By
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CERTIFICATE

Certified that this report titled " **A Blueprint for Sustainable Solid Waste Management in Urban Areas: Case Study Hardwar"**, which has been submitted by Major Rana Banerjee, in partial fulfilment of the requirements for the award of Post Graduate degree in Master of Urban and Rural Planning in the Department of Architecture and Planning, University of Roorkee, Roorkee, is the student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree.

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in this thesis entitled " **A Blueprint for Sustainable Solid Waste Management in Urban Areas: Case Study Hardwar**" in partial fulfilment of the requirement for the award of the degree of **Master of Urban and Rural Planning** submitted in the Department of Architecture and Planning, of the University of Roorkee, is an authentic record of my own work carried out during the period from August 2000 to February 2001 under the supervision of Mr. R. Shankar, Professor, in the Department of Architecture and Planning, University of Roorkee, Roorkee, India.

The matter embodied in this thesis has not been submitted by me for the award of any other degree.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Whatever man uses, and also all that he makes for his use will inevitably becomes waste. Although humans and animals have used the earth's natural resources since evolution to support their lives and also to dispose their waste, what their small primitive populations widespread and few, generated as waste, posed no problems for the environment. But as humans began to congregate in larger and larger settlements, the accumulation of waste became a consequence of life. Littering of food and other solid wastes in medieval towns- the practice of throwing wastes into the unpaved streets, roadways and vacant land- led to the breeding of rats, with their attendant fleas carrying the germs of disease, and the outbreak of plague. The lack of any plan for the management of solid wastes led to the epidemic of plague, the Black Death, that killed half of the Europeans in the fourteenth century and caused many subsequent epidemics and high death tolls. It was not until the nineteenth century that public health control measures became a vital consideration to public officials who began to realize that food wastes had to be collected and disposed off in a sanitary manner to control the vectors of diseases ***(Tchobanoglous, et el,1977)***.

Unfortunately for us, in India the issue of management of solid waste had not received its due attention and ill informed, disinterested and corrupt municipal authorities paid scant notice to heaps of garbage in many of the large cities. The plague epidemic in Surat ensued, claiming about a hundred lives, causing national shame and outrage on the precarious public health conditions prevalent. Although it was a well-established fact that there is a direct relationship between public health and improper storage, collection and disposal of solid waste, public apathy and neglect by municipal authorities precipitated a plague epidemic in modern India basking in the glory of technological and industrial advancement. For policy and decision-makers, administrators, technocrats and planners the issue was one of grave import. And the problem of Solid Waste Management (SWM) was in focus, belatedly, after taking its toll.

Half a decade later, today, the manifestation of advancements in technology, communications and most importantly information technology is finally perceptible to the populace, especially in urban areas, but yet the situation pertaining to Water Supply, Environmental Pollution, Sanitation and Solid Waste Management (SWM) remains dismal and problematic. The threats persist and the fear of another Surat re-happening remains even today in many of our cities.

The necessary and adequate management of all the above issues requires substantial changes and consequent disturbance in the existing urban form and structure, physical or otherwise. However, the appropriate management of solid waste is an issue, which requires minimal changes and disarrangement of existing settlement systems.

The sustainability of development in our urban areas requires that we stop degrading the urban environment. In light of the deplorable condition of our cities and towns, the planners can no longer be insulated from the pertinent threats posed to urban development by the solid wastes. All human settlements have to take responsibility for their wastes and render it safe for posterity while ensuring that the process of Solid Waste Management (SWM) itself remains sustainable.

1.2 DEFINING NEED FOR THE STUDY

The world today faces three major problems, problems that require global attention and concentrated efforts transcending barriers of boundaries, isms and faiths. These are:

(a) Population

(b) Energy

(c) Wastes

Every process of human endeavour is belittled by the massive requirements of an ever-increasing population's demand for food, energy and implements; and with each process associated with meeting these demands is the generation of waste. Figure 1-1 gives the simplified materials flow diagram showing how and where solid wastes *are generated in our technological society* ***(Tchobanoglous, et el, 1993)***.

Thus we see that every process of production and consumption has as an inseparable and inevitable process- waste generation. The more advanced a society, more is the consumption, which in turn leads to increased production. And both production and consumption lead to increased waste generation. Logically so, we find that the developed countries have much higher rates of generation of solid wastes than the developing and under-developed countries.

However in the Indian context, with an estimated urban population of 297 million in 2001 and expectations of further growth to 549 million by 2021 (***Tewari, Vinod, 1997***), the total quantities of waste generated would be colossal. With wide ranging and adverse environmental, ecological and public health implications the management of the urban solid waste is an issue which can no longer be dealt with in a lackadaisical manner or an "Out of Sight, Out of Mind" approach, as done hithertofore.

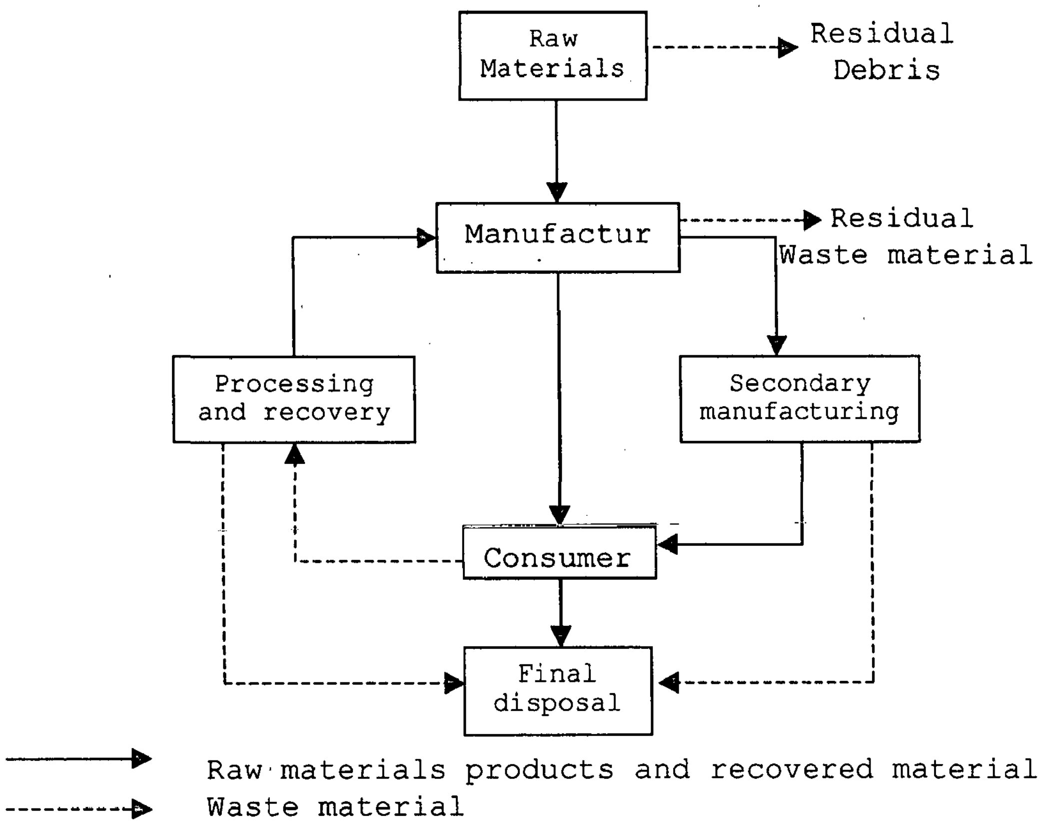


FIGURE 1-1. MATERIALS FLOW AND GENERATION OF SOLID WASTES IN A TECHNOLOGICAL SOCIETY.
(Source: Tchobanoglous, et el, 1977)

As far back as 1967 the U.S Public Health Service (U.S.P.H.S.) had published the results of a study tracing the relationship of 22 human diseases to improper solid waste management- dysentery, cholera, plague, typhoid, infective hepatitis to name a few. Studies have also shown that workers engaged in collection and disposal of solid wastes are exposed to high health risks and frequently suffer from respiratory tract infections, gastro- intestinal parasites and worms (***Satpal Singh, 1999***). So, with Indian conditions of grossly inadequate medical and health facilities it is pertinent to evolve strategies for management of solid wastes in urban areas due to the high population densities and inadequate infrastructural framework.

The rural areas of our country are comparatively better off on this front, primarily due to the following reasons:

(a) The Indian traditional and cultural ethos predominantly governs the way of rural life and it promotes the concept of least generation of waste and maximum reuse and recycling.

(b) The Indian rural population is not as consumeristic as its urban counterpart and consumption is a function primarily of needs. So wastes generated rarely have the degrading capabilities as that in urban areas.

There is a growing awareness world over of the depletion of non-renewable resources, more so in the developed countries. A highly populated nation like ours with resources manifold lesser than many developed countries, cannot be so irresponsible to be insulated to this fact. We more than any other need to optimise our utilization of the diminishing resources and recover, recycle and reuse all that can be. And the massive quantities of wastes generated have in them tremendous resource potential.

The resource and economic potential of solid wastes do not permit the luxury of letting the wastes be lost for any further use, especially for a country like India. As such it is pertinent to evolve appropriate and viable Solid Waste Management (SWM) strategies for our urban areas.

In a highly populated country like India, where the unemployment rate is so high, we find that the waste recycling industry provides major opportunities to the economically weaker sections of the society. Traditionally, the economically backward people used to be largely involved in sanitation and conservancy jobs in urban areas. These people have played an important role in keeping those parts of the cities clean where their endeavour was suitably rewarded by the individual affluent households. Along with this they also earned money by recycling whatever materials they could recover from the solid wastes. Thus, these private players earned their daily bread even as they contributed to the cleanliness of certain pockets of the cities. Even today in the absence of automated process of collection, transportation, treatment and disposal of solid wastes in India and the prevalence of labour intensive technologies for Solid Waste Management (SWM), there is a vast potential for providing people gainful employment opportunities in this industry.

From the foregoing, it is established that for the sustainable health and development of our urban areas we have to realize fully the importance of Solid Waste Management (SWM) and evolve appropriate systems which are technically feasible, economically viable and socially acceptable and incorporate the same into the very planning process for urban areas.

1.3 OBJECTIVES OF THE STUDY

The following are the objectives of the study:

a) To study the existing phenomenon, principles and practices of SWM in urban areas and to analyse the various issues in the context of appropriate technology, economic feasibility and sustainability, public response, environmental implications, urban planning and development.

b) To analyse the existing practices and problems of SWM in urban India in general and Hardwar in particular and to bring out relevant findings and draw useful lessons.

c) To develop a sustainable action plan for SWM in Hardwar including institutional arrangements and community participation programmes.

d) To develop general planning and development guidelines pertaining to urban SWM practices arising out of the aforementioned studies.

1.4 SCOPE OF THE STUDY

The project would be restricted to the study of urban SWM practices of a limited number of international cities and to more elaborate studies on Indian cities based on available literature and secondary data. Though the city of Hardwar is taken up for the detailed study of prevailing SWM practices and proposing an action plan for integrated SWM in its urban area, both under normal and special circumstances, the strategies will have relevance to other Indian cities also.

1.5 METHODOLOGY

The methodology, which has been followed for the study is given in Figure 1-2.

1.6 LIMITATIONS OF THE STUDY

The following limitations are envisaged:

a) Due to the limitations of available time the field studies have been restricted to mainly the most pertinent and feasible ones.

b) No long-term study of the issue, its implications and impact studies was feasible due to the limitations of resources.

c) For reasons best known to them the government organisations were reluctant to reveal the facts regarding wastes and current expenditure pattern on waste management. Logical 'guesstimates' had to be resorted to in the absence of relevant data.

d) Certain baseline assumptions have been made (e.g. composition of solid waste generated) based on detailed studies done in other Indian cities for analysis, projections and plan proposals.

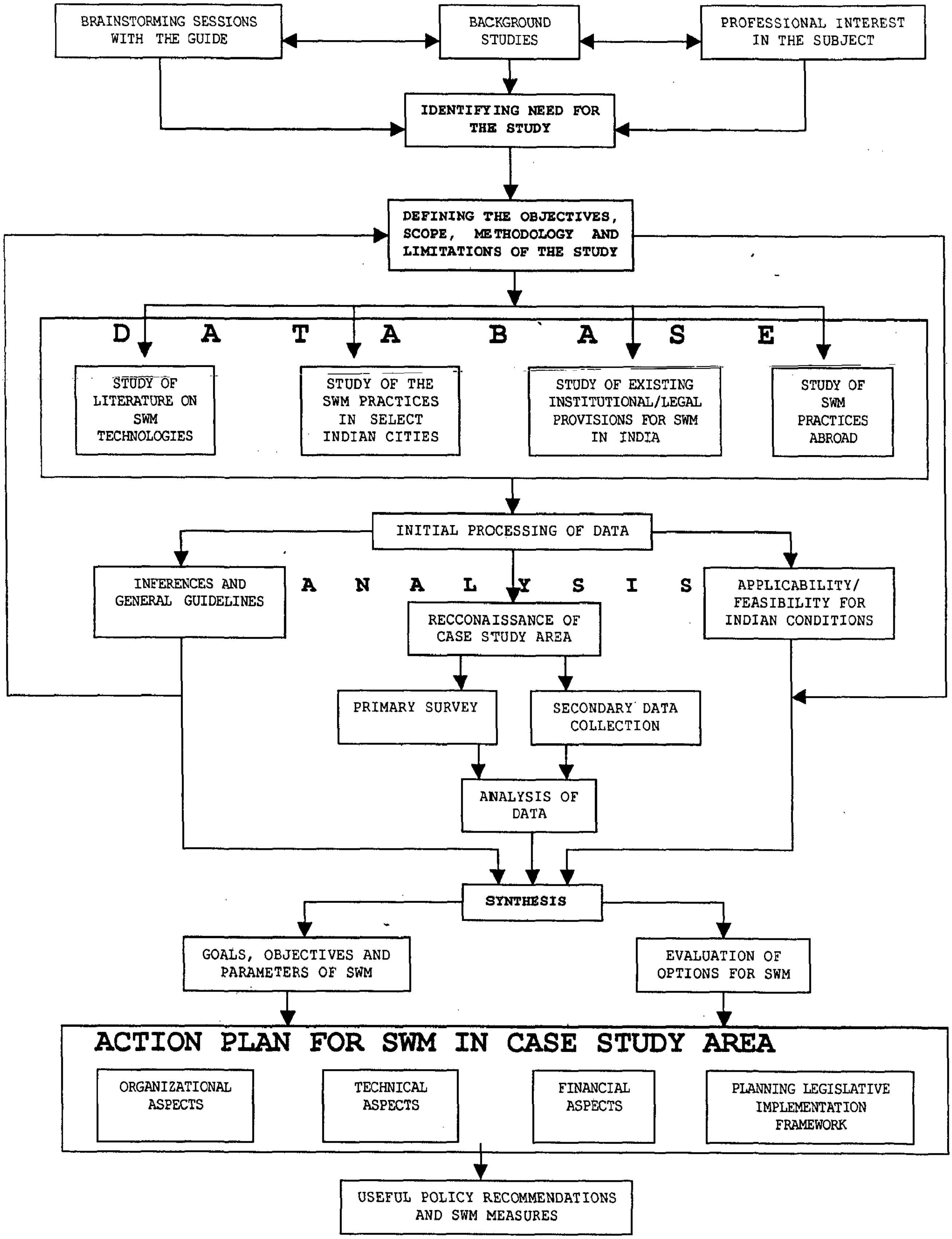


FIGURE 1-2: METHODOLOGY CHART

CHAPTER 2

BASICS OF SOLID WASTE MANAGEMENT: PRACTICES IN DEVELOPED COUNTRIES

2.1 SOLID WASTE MANAGEMENT IN LITERATURE

The subject of Solid Waste Management has assumed enormous significance world over in the last few decades due to the realization, mainly in the developed countries, of the adverse impacts of failure to manage the urban Solid Wastes. The deteriorating urban environment, the degradation of the urban ecosystems and the fast depletion of natural resources have coerced the intelligentsia to look for the causes, that are manifest in these effects.

In the European and American countries, due to the economic and technological advancements, there has been much thought and action resourced to these problems. These have resulted in numerous studies, researches, papers, books and journals to concentrate wholly on issues pertaining to the subject of Solid waste Management. Many of these form the basis of all further technological advancements in the subject. However due to constraints of time and resources, it is not practicable to access all the wealth of knowledge offered by these. But it is mandatory to acquire a working knowledge of the basic tenets of the subject and the technologies involved, to be able to plan effectively, for the management of Solid Wastes.

Tchobanoglous, et el, 1993, in their book 'Integrated Solid Waste Management Engineering Principles and Management Issues' defines Solid Waste Management (SWM) as that discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations, and that also is responsive to the public attitudes.

Wilson, David G., 1977, also considers the above mentioned parameters as the essential aspects of SWM in his 'Handbook of Solid Waste Management'. David C. Wilson in his book 'Waste Management: Planning, Evaluation, Technologies' deals with the subject taking into consideration the same principles.

In its scope Solid Waste Management (SWM) includes all administrative, financial, legal, planning and engineering functions involved in the whole spectrum of solutions to problems of solid waste.

The SWM practices are highly evolved and incorporate state-of-the-art technology in most developed countries. It was not always so. Even as late as the middle decades of twentieth century, many European countries and the U.S.A. were suffering the ill effects of pollution and environmental degradation due to extensive industrialization.

The concentrated efforts of environmentalists, engineers, planners, and above all the population itself went into controlling the ill-effects of wastes and thereafter the SWM practices which were appropriate for each situation evolved through conscious endeavour of all concerned. Today most developed and industrialized nations have very elaborate, sophisticated and sustained SWM practices, which are models for developing countries.

2.2 FUNCTIONAL ELEMENTS OF SOLID WASTE MANAGEMENT

There are six functional elements that constitute Solid Waste Management (SWM) systems. ***(Tchobanoglous, et el, 1993)***:

1. Waste generation.
2. Onsite handling, Storage and Processing.

3. Collection.

4. Transfer and Transport.

5. Processing and Recovery.

6. Disposal (Landfilling).

The adoption of appropriate technology for each of the six functional elements of SWM is a characteristic of the SWM practices in developed countries. The developed countries have a system of scientific evaluation of all functional elements and all of the interfaces and connections between elements are matched for effectiveness and economy. Strict legislative measures control each activity associated with SWM. There are specific laws and regulations with harsh and binding punitive measures, which govern storage, collection, transportation, processing and disposal of solid wastes. The common practices adopted for each of the function are discussed in later sections.

The aforementioned functions however vary for different categories of waste. The categorization of waste may be based on a number of criteria as listed below:

a) Source of generation

b) Material Composition

c) Reuse, recovery and processing potential

d) Environmental consideration

The whole process of SWM is shown in Figure 2-1 below.

2.3 TYPES OF SOLID WASTES

Solid Wastes may be classified according to the source of generation (***Wilson, David G., 1977***), as given below:

(a) <u>*Residential wastes*</u>

These are the wastes that are generated during the routine of household activities, within the residential premises. These generally comprise of food wastes, paper, textiles, plastic, glass and ceramics, rubber, leather, grass and leaves and other inert materials. However the quantity and composition varies largely on the type of housing, economic status of residents, season and socio-cultural practices of the community.

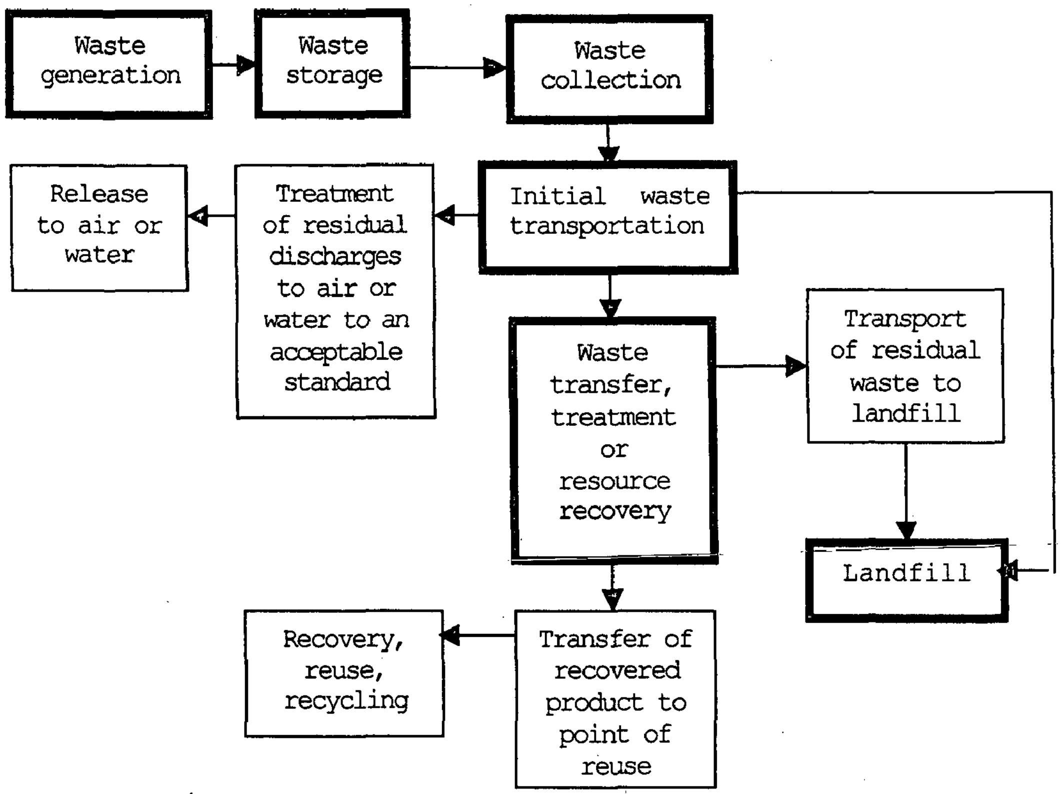


FIGURE 2-1: GAMBIT OF SOLID WASTE MANAGEMENT.
(Source: Tchobanoglous, et el, 1977)

(b) *Commercial wastes*

The composition of commercial solid waste is similar to that of residential waste, but individual generation points tend to produce more homogeneous waste stream. Also the amount of solid waste generated per collection unit is much higher for a commercial waste source than for a residential solid waste source; as a result, collection vehicles in commercial areas fill up rapidly.

(c) *Industrial waste*

Industrial wastes comprise of packing materials, food processing residues, spoiled metals, plastic, textiles, residues of burnt fuels and spent processing chemicals. The large quantities of industrial wastes and often their toxic or polluting nature pose a problem. Increased application of air and water pollution controls will increase the solid wastes destined for hand disposal thus aggravating the problem. The industrial waste generation quantities depend on the type of industries and their sizes.

(d) *Construction and Demolition wastes*

Solid wastes arising out of construction activities and demolition of existing structures belong to this category. These wastes generally comprise of stone, rubble, broken concrete, asphalt, brick, plaster, wallboard, pipe, wire, timber and other such residual building materials. Although these wastes are not toxic or hazardous, in case of large-scale development, their disposal requires large areas of land.

(e) *Bulky Wastes*

Large and bulky items like furniture, refrigerator abandoned automobiles, tyres, poles and other large appliances comprise the bulky wastes. The collection of these wastes requires special vehicles, as conventional collection vehicle may not be able to collect these. These also have to be reduced in size before disposal, to save valuable space. However in India, due to the very high rate of recycling of such items these wastes are much lesser than in western countries.

(f) *Hazardous waste*

These are wastes with high concentration of pathological, radioactive or explosive materials. The collection and transportation of these wastes requires trained personnel and specialized equipment. The disposal of these wastes in most countries is regulated by strict rules.

(g) *Institutional waste*

The institutional sources of solid wastes include schools, prisons, government centres and hospitals. The waste composition of the solid wastes generated in the prisons and hospitals is quite similar to commingled residential and commercial Municipal Solid Waste (MSW), excluding the manufacturing waste from prisons and the medical wastes from the hospitals.

2.3.1 MUNICIPAL SOLID WASTE (MSW)

The generic term Municipal Solid Waste (MSW) refers to all solid wastes generated in the area of responsibility of a municipal body and is generally comprised of the following:

a) Residential Wastes

b) Commercial Wastes

c) Institutional wastes

d) Construction and Demolition wastes

e) Bulky wastes

f) Hazardous wastes

However, industrial wastes are not included in the Municipal Solid Wastes and its management is not within the purview of Municipal Solid Waste Management.

2.4 WASTE GENERATION

Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. Waste generation is an activity that is presently not very controllable in most developed countries. Due to higher incomes and greater consumption of consumer goods the waste generation rates in developed countries is much higher than that in developing countries. The per capita Municipal Solid Waste (MSW) generated, in the year 1990 in California and Florida are 1134 Kg and 998 Kg approximately ***(Tchobanoglous, et el, 1993)***.

Table 2-1 illustrates the generic quantitative and qualitative characteristics of the solid wastes generated in industrialized, middle income and low-income (synonymous to developing) countries.

Category of the Country	Quantity Generated Kg/capita/day	Density Kg/cu.m	Percent Moisture
Industrialised Countries	0.7 to 1.8	100 to 170	20 to 30
Middle Income Countries	0.5 to 0.9	170 to 330	40 to 60
Low Income Countries	0.4 to 0.6	250 to 500	40 to 80

TABLE 2-1: GENERALISED QUANTITIES AND CHARACTERISTICS OF URBAN REFUSE
(Source: Cointreau, Sandra J.,1982)

The per capita waste generated in some of the cities in the industrialized, middle-income and low-income countries are given respectively in Table 2-2 below:

City or Country	Waste Generation Rate Kg/capita/day
Industrialized Countries	
New York, U.S.A.	1.8
Hamburg, Germany	0.85
Rome, Italy	0.69
Middle Income Countries	
Singapore	0.87
Hong Kong	0.85
Manila, Philippines	0.50
Low Income Countries	
Calcutta	0.51
Kanpur	0.50
Jakarta	0.60

TABLE 2-2: URBAN REFUSE GENERATION RATES
(Source: Cointreau, Sandra J., 1986)

The situation pertaining to waste generation, its composition and characteristics in developed and western countries are distinctly unlike that in India and thus the adoption of any western model is unsuitable for Indian situation. Table 2-3 gives the generalized composition in some cities of developed/ industrialized, middle and low income countries. The following points emerge from the study of the tables 2-1 and 2-3:

a) Solid wastes in developed countries have much lesser proportion of organic materials. The reason being that in the developed countries the consumption of tinned and pre-cooked food is more common than preparation of fresh food from raw vegetables.

b) Waste densities are low due to high percentage of non-putrescibles, such as paper, plastics, glass and metals, arising mostly from packaging of consumer goods.

c) The moisture content of wastes is also low thus significantly affecting the treatment process to which the waste has to be subjected.

d) The calorific value is high, and so processes like incineration become viable due to low fuel requirements.

2.5 ONSITE HANDLING, STORAGE AND PROCESSING

The handling and separation, storage and processing of solid wastes at the source has a significant effect on the characteristics of the waste, on the subsequent functional elements and on public health. There is an obvious effort by municipal authorities in developed countries to ensure the best possible treatment at this elementary stage of SWM processes.

Onsite handling primarily involves compaction of the wastes by the producers and placing the wastes in the storage containers. In case of high-rise buildings it involves the movement of wastes from various floors to the service area manually or through specially designed vertical chutes with openings located on each floor.

2.5.1 STORAGE AT SOURCE

The proper storage of solid wastes prior to collection prevents excessive malodour, attraction of vectors, spoiling aesthetics and environmental pollution. The storage devices used for storing solid wastes should necessarily facilitate safe collection, transportation, processing and disposal. The different types of storage devices that are generally used (***Wilson, David G., 1977***) are listed below:

(a) *Containers*

These should be rigid and of durable metal or heavy plastic. These should have tight fitting covers. The size of the containers should be such that it can be carried, handled and emptied into the collection vehicle by one person. These should have strong and convenient pick-up handles to facilitate easy manual carriage and also to prevent injuries to the user, or collector.

	Industrialised			Middle Income			Low Income	
Type of Material (in percentage by weight)	Brooklyn New York	London England	Rome Italy	Singapore	HongKong	Manila	Lucknow	Calcutta
Paper	35	37	18	43	32	17	2	3
Glass, ceramics	9	8	4	1	10	5	6	8
Metals	13	8	3	3	2	2	3	1
Plastics	10	2	4	6	6	4	4	1
Leather, rubber	-	-	-	-	-	2	-	-
Textiles	4	2	-	9	10	4	3	4
Wood, bones, straw	4	-	-	-	-	6	<1	5
Non-food Total	74	57	29	63	60	40	18	22
Vegetative, Putrescible	22	28	50	5	9	43	80	36
Miscellaneous Inerts	4	15	21	32	31	17	2	42
Compostable Total	26	38	71	37	40	60	82	78
Total	100	100	100	100	100	100	100	100

TABLE 2-3: URBAN REFUSE COMPOSITION DATA.
(Source: Cointreau, Sandra J., 1982)

(b) *Bags*

Plastic and paper storage bags are also used for storage of solid wastes at generation point. They offer certain advantages as given below:

(i) One-way disposal without retrieval.

(ii) A universal and standard-size, cleaners container.

(iii) Faster collection because they are not required to be emptied and returned.

(iv) Spillage and resultant litter is reduced.

(v) Easier storage and handling.

(vi) Home lesser injury potential for user and collector due to lighter load and ease of handling.

(vii) More sanitary and cause less noise, dust, odour and micro-organism release.

(viii) Are also adaptable to mechanized collection by vehicular equipment.

However these also have some disadvantages listed below:

(i) Are punctured easily by sharp objects.

(ii) Dogs, cats and rats can easily tear the bags open.

(iii) These are a continuing cost.

(iv) Plastic bags themselves contribute to solid waste.

(c) *Drop Boxes*

Drop boxes are large storage bins. These may or may not have compactors. The cost of these drop boxes is lesser than that of smaller bins, bags or can, per unit of solid waste. Appropriately located large boxes of 20 to 40 cubic meter capacity can service a large area. Accordingly the vehicles capable of lifting these boxes can be used for collection and transport. When a full box is collected, it is replaced by an empty box.

(d) *Other Storage Devices*

Underground pit storage and backyard solid waste shelters require emptying by a collection crew using hand tools and are inefficient, cause odors, support rats, flies, and other vermins and create a fire hazard. In addition to the above there is the loss of space associated with such devices.

However in case of all storage devices, the sizes and numbers are intrinsically related to the collection methods and frequency. The types and capacities of containers used generally depend on the characteristics and types of solid wastes to be collected, the type of collection system in use, collection frequency and the space available for the placement of container.

The typical applications and limitations of different types of containers used for onsite storage of solid wastes in the developed countries are given in the Table 2-4. It is pertinent to note that the proper storage of solid wastes is an important initial process that affects all the other processes to which the solid waste is thereafter subjected.

CONTAINER TYPE	TYPICAL APPLICATIONS	LIMITATIONS
Small Container, plastic or galvanised metal	Very low volume waste sources, such as individual homes, walkways in parks, and small isolated commercial establishments; low rise residential areas with setout collection service.	Containers are damaged over time and degraded in appearance and capacity; containers add extra weight that must be lifted during collection operations contai-ners are not large enough to hold bulky wastes.
Disposable paper bags	Individual homes with packout collection service; can be used alone or as a liner inside a household container; low and medium rise residential areas.	Bag storage is more costly; if bags are setout on streets or curbside, dogs or other animals tear them and spread their contents; paper bags themselves add to waste load.
Disposable plastic bags	Individual homes with setout collection service; can be used alone or as a liner inside household container; for cold	Bag storage is more costly; bags tear easily, causing litter and unsightly conditions; bags become brittle in very cold conditions, causing

CONTAINER TYPE	TYPICAL APPLICATIONS	LIMITATIONS
	climates, bags are useful in holding wet garbage inside household containers as well as in commercial containers; low, medium and high rise residential areas; commercial areas; and industrial areas.	breakage; plastic lightness and durability causes disposal problems.
Medium Container	Medium volume waste sources that might also have bulky wastes; location should be selected for for direct collection truck access; high density residential areas; commercial areas; industrial areas.	Snow inside the containers forms ice and lowers capacity while increasing weight; containers are difficult to get to after heavy snows.
Large Container, open top	High volume commercial areas bulky wastes in industrial areas; low density rural residential areas; location should be within a covered area but with direct-collection truck access.	Initial cost is high; snow inside containers lowers capacity.
Container used with stationary compactor	Very high volume commercial areas; location should be outside buildings with direct collection truck access.	Initial cost is high; if container is compacted too much, it is difficult to unload it at the disposal site.

TABLE 2-4: TYPICAL APPLICATIONS AND LIMITATIONS OF CONTAINERS USED FOR THE ONSITE STORAGE OF SOLID WASTES (Source: Tchobanoglous, et el, 1977)

2.5.2 SEGREGATION OF SOLID WASTES AT SOURCE

The most convenient and easy method of solid waste separation is the segregation provided by the producer. Segregated materials have minimum contamination, but require special equipment and extra handling.

The main purpose of waste segregation is to promote resource conservation. Also segregation of solid wastes can go a long way to ensure appropriate disposal. The source segregation of metal, paper and other valuable components are potential starting points for recovery and recycling.

In many countries, segregation of solid wastes at the source has been mandated by law. The segregation of solid wastes' components including wastepaper, cardboard, aluminium cans, glass, and plastic containers at the point of generation is one of the most positive and effective ways to achieve the recovery and reuse of materials. Once the waste components are segregated, the waste-owner stores the separated components within the home, periodically transferring the accumulated wastes to larger containers used for storage of these materials between collections. The other option is to separate the wastes and place them directly in the larger containers.

2.5.3 PROCESSING AT THE GENERATION POINTS

Many households, in developed countries have arrangements for compaction of solid wastes. These help to reduce the storage requirement. The practice of home composting as a means of recycling organic materials is also popular in developed countries. Burning of combustible materials in the fireplace and burning of rubbish in backyard incinerators was a common practice but backyard incineration is banned in most countries now due to associated air pollution by toxic gases. Presently in most developed countries processing at generation point involves shredding, sorting, compacting and composting at the household level.

Depending on the composition of wastes from varied sources the environmental engineers devise suitable collection, treatment and disposal schemes.

2.6 COLLECTION OF SOLID WASTES

Collection includes gathering and picking up of solid wastes from the various sources and hauling of these wastes to the location where the collection vehicles are emptied. The unloading of collection vehicles also considered part of the collection operation. Most collection vehicles used are either self-loading or have a mechanical loading system. However, where separation of wastes at source is practiced, even manual loading is practiced, if no hazardous wastes are being handled.

Very sophisticated automated collection vehicles are in use in many of the developed countries. These vehicles do not require any collection crew, instead they have hydraulic or pneumatic arms, which pick up the containers and empty it into the waste compartment of the vehicle. Each type of vehicle has a prototype container. Some vehicles also have an in-built compactor to allow greater tonnage per trip. Such sophisticated equipments, inspite of being expensive, are cost effective as they eliminate the risk posed to human collectors by the wastes.

The collection vehicles are invariably enclosed and water tight to facilitate all weather service. Open vehicles are generally used only for collection of bulky wastes.

For collection of solid wastes many combinations of collection vehicles, crew size, collection frequency etc are used. The local conditions dictate the selection of the most appropriate collection system. Some of the common collection services practiced in developed countries (***Wilson, David G.,1977***) are explained below:

(a) *Curb Collection*

In this system collectors pick-up the waste containers from the curb, dump the waste in the vehicle and return the containers to the curb. The house-owner is responsible for placing the filled container on the curb on collection days and also for picking up the empty container from the curb and carrying it to his premises.

(b) *Alley Collection*

This system requires that the containers be stored within the premises of the producer but in proximity to the alley. Both sides of the alley are generally picked up simultaneously. The waste containers are emptied into the collection vehicle by the collector.

(c) *Backyard Collection*

In this system the collectors remove refuse from the containers placed in the backyards of the premises and return the container. This type of collection eliminates the cluttering of curbs with waste containers and their litter. But this type of service is more costly and requires the collectors to enter private property. There are different variations of the backyard collection, which are adopted in different places.

Collection systems are also classified according to their mode of operation (***Tchobanoglous, et el, 1977***) into two categories:-

(a) *Hauled container systems*

These are collection systems in which the container used for the storage of wastes are hauled to the disposal site, emptied and returned to their original location or some other location.

(b) *Stationary container systems*

In this collection system the container used for the storage of wastes remains at the point of generation, except for occasional short trips to the collection vehicle.

Collection is one of the most important functional elements of SWM and its efficiency is the most perceptible of the six functions. In the U.S. collection accounts for almost 50 percent of the total annual cost of urban solid waste management and this service costs individual house-owners upto $200 per year (1990) depending on the number of containers and frequency of collection ***(Tchobanoglous, et el, 1993)***.

2.7 TRANSFER AND TRANSPORTATION

In SWM, the functional element of transfer and transport refers to the means, facilities and appurtenances used for transferring wastes from one location to another. In the process, usually the contents of small collection vehicles are transferred to larger vehicles which are then used to transport the waste over long distance either to Materials Recovery Facilities (MRFs) or to disposal sites. The transportation of recovered material to market or waste-to-energy facilities and transportation of residual materials to landfills also comes within the purview of transfer and transport.

In developed countries various means and methods used for transportation are:

(a) Motor vehicles
(b) Railroad
(a) Ocean-going vessels
(b) Pneumatic and Hydraulic means

The motor vehicles are the most commonly used means for solid waste transportation. Motor vehicles used for hauling solid wastes are required to satisfy the following requirements:

(a) Wastes must be transported at minimum cost
(b) Wastes must be covered during the haul operations
(c) Vehicles must be designed for highway traffic

(d) Vehicle capacity must be such that the allowable weight limits are not exceeded.

(e) Methods used for unloading must be simple and dependable.

The railroad transportation of solid wastes is very rarely used nowadays, but it is a viable option if the landfill site is very far and highway travel is very far and highway travel is very difficult. However, the requirements of waste containers are same as for motor vehicles. Solid waste from Seattle was transported to Columbia Ridge landfill by train in 1990s. (***Tchobanoglous, et al, 1993***)

Pneumatic and Hydraulic systems of transport of solid wastes are also used. The most common application is the transport of wastes from high-density apartments or commercial activities to a central location for processing or for loading into transport vehicles. The largest pneumatic system is installed in the Walt Disney World amusement part at Orlando, Florida.

Hydraulic transport is very commonly used in developed countries especially for the transport of a portion of food wastes (where home grinders are used) one of the major problems with this method is that ultimately the wastewater used for transporting the wastes must be treated. Hydraulic systems require proper pre-processing and post-processing facilities to be incorporated into the treatment system.

2.7.1 TRANSFER STATIONS

When the processing or disposal sites are so far from the collection points that it is uneconomical for collection vehicles to transport their tonnage to disposal sites, then the transfer station is used for dumping the wastes. From the transfer station larger quantities of wastes are transported to disposal sites in vehicles with greater capacity. To make the transfer more economical, the wastes are generally compacted to reduce volume. Methods like shredding and high density baling not only increase the haul vehicle's carrying capacity but also reduce operating cost. Processes like baling also make handling of the waste easier. However transfer stations are typically odorous, noisy and dusty. These also require vehicular traffic control system and have to be weather proof.

In the developed countries, there is a trend of establishing Materials Recovery/Transfer Facilities (MR/TFs). The MR/TFs may include the functions of drop-off centre, separation, composting, bioconversion processes, production of refuse-derived fuel (RDF) and transport. The use of large MR/TFs affects cost savings that are possible by combining several waste management activities in single facility.

Transfer Stations may be classified according to their capacities or according to the method used to load the transport vehicles. (***Tchobanoglous, et el, 1977***)

Classifications according to capacities are:

(a) Small - Handling less than 100 ton/day.

(b) Medium - Between 100 and 500 tons/day.

(c) Large - More than 500 tons/day.

Classifications according to loading method are:

a) *Direct discharge transfer station*

The wastes in the collection vehicles are emptied directly into the vehicle to be used to transport them to a place of final disposition.

b) *Storage Discharge transfer station*

The wastes are emptied either into a storage pit or onto a platform from which they are loaded into transport vehicles by various types of auxiliary equipment.

c) *Combined Direct and Storage Discharge Transfer Station*

Both the methods are used.

2.8 PROCESSING AND RECOVERY

The recovery of separated materials, the separation and processing of solid waste components, and transformation of solid wastes that occurs primarily in locations away from the source of waste generation are encompassed by this functional element.

Processing often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, size reduction by shredding, separation of ferrous metals by using magnets, volume reduction by compaction and combustion.

Transformation processes are used to reduce the volume and weight of waste requiring disposal and to recover conversion products and energy. The organic fraction of municipal solid waste (MSW) can be transformed by a variety of chemical and biological processes. The most commonly used chemical transformation process is combustion, which is used in conjunction with the recovery of energy in the form of heat. The most commonly used biological transformation process is aerobic composting.

2.8.1 PROCESSING TECHNIQUES

Since the Municipal Solid Waste (MSW) in an "as collected" state is biologically unstable, can become odorous and is essentially unusable. The usable materials and organic portions are separated and thereafter processed according to its disposal method. Both, the commingled waste as well as waste separated at the source, are further separated at MRFs and processed to achieve the following:

a) Modify the physical characteristics of the waste so that waste components can be removed more easily and

b) To remove specific components and contaminants from the waste stream.

Processing techniques are used in SWM systems to improve the efficiency of operations, to recover resources i.e. usable materials, and recover conversion products and energy.

The various techniques of processing of solid wastes (***Tchobanoglous, et el, 1977***) are:

(a) Mechanical volume reduction (Compaction)

(b) Chemical Volume reduction (Incineration)

(c) Mechanical size reduction (Shredding)

(d) Component separation (Manual and mechanical)

(e) Drying and dewatering (Moisture content reduction)

These techniques are briefly discussed in the following paragraphs.

(a) *Mechanical Volume Reduction*

Volume reduction is an important factor in the development and operation of all SWM systems. It enables greater collection and transportation of solid wastes by means of compaction. It also increases the useful life of landfills. Even material for recycling are compacted and transported.

(b) *Chemical Volume reduction*

Processes such as open-burning, incineration, pyrolysis, hydrolysis and chemical conversion are effective method for reducing the volume of solid wastes. However most of these methods are primarily used for recovery of products. The most commonly used volume reduction method is incineration but it is invariably linked with recovery of materials. Most incineration processes are able to reduce the volume of solid wastes to about 5 % or less (Tchobanoglous, et el, 1977). However, the discharge of gaseous products of combustion have to be monitored and controlled to prevent air pollution.

(c) *Mechanical Size Reduction*

Size reduction is the term applied to conversion of solid wastes as they are collected into smaller pieces. The objective of size reduction is to obtain a final product that is reasonably uniform and considerably reduced in size in comparison to its original form. Shredding, grinding and milling are the most common methods of mechanical size reduction.

(d) *Component separation*

Component separation is an essential process for resource recovery from solid wastes. The required separation may be accomplished manually or by mechanical means. The most common methods are component separation (***Tchobanoglous, et el, 1977***) are:

(i) Handsorting

(ii) Air separation

(iii) Magnetic separation

(iv) Screening

(v) Inertial separation

(vi) Floatation

Component separation is use to transform a heterogeneous waste into a number of more-or-less homogeneous components. Components separation is a necessary operation in the recovery of reusable and recyclable materials from MSW, in the removal of contaminants from separated materials, in the removal of hazardous wastes from MSW, and where energy and conversion products are to be recovered from processed wastes.

(e) *Drying And Dewatering*

In most solid waste energy recovery and incineration systems, the shredded light fraction is pre-dried to decrease weight by removing varying amounts of moisture, depending On process requirements. Drying is accomplished by one or more of the following methods (***Tchobanoglous, et el, 1993***):

(i) Convection, in which the heating medium, usually air or the products of combination, is indirect contact with the wet material.

(ii) Conduction in which the heat is transmitted indirectly by contact of the wet materials with a heated surface.

(iii) Radiation in which heat is transmitted directly and solely from the heated body to the wet material by the radiation of the heat.

There are many different dryers available and most SWM processing plants in developed countries employ sophisticated drying equipment. Dewatering processes are used primarily to reduce the liquid volume of municipal wastewater. Once dewatered the sludge is mixed with other solid wastes and the resulting mixture is:

(i) Incinerated to reduce the volume.

(ii) Used for production of recoverable by-products.

(iii) Used for the production of compost.

(iv) Buried in a landfill.

2.8.2 RECOVERY OF RESOURCES AND ENERGY

Solid wastes contain, as their components, materials that may be of value as a source of raw materials for industry, fuel for the production of power and materials that can be used for the reclamation of land.

The recovery of materials resources and energy from solid waste also results in drastic reduction of materials left for final disposal. Thus the process of recovery also reduces the environmental degradation due to solid wastes.

Recycling of materials found in MSW involves the following:

(a) the recovery of the material from the waste stream,

(b) intermediate processing such as sorting and compaction,

(c) transportation and

(d) final processing, to provide a raw material for manufacturers or an end product.

The primary benefits of recycling are conservation of natural resources and landfill space; however, the collection and transportation of materials requires substantial amounts of energy and labour. The requirements for a successful recycling programme are that a strong demand exists for recovered materials and that the market value of the materials be sufficient to pay for the collection and transportation costs.

The waste management authorities at both the central government levels and local government levels in the European countries, as well as private entrepreneurs are seeking less expensive alternatives for solid waste disposal but more importantly the efforts are mainly directed towards the realization of some of the materials and the off-site utilization of energy values that are inherent in municipal solid wastes.

The various methods used for processing and recovery of individual waste components from MSW are tabulated in Table 2-5.

There are many different types of unit operations in practice in developed countries for each of the processes mentioned in the table above. Most of these unit operations plants employ advanced technologies and state-of-the-art equipment, thus producing the exact configuration of the waste, in terms of size, weight, density or

PROCESSING OPTIONS	DESCRIPTION
Size Reduction	Unit operation used for the reduction of both commingled MSW and recovered material. Typical applications include 1) Hammermills for shredding commingled MSW; 2) Shear shredders for use with commingled MSW and recycled materials such as aluminium, tyres and plastics; and 3) tub grinders used to process yard wastes.
Size Separation	Unit operations in which materials are separated by size and shape characteristics, most commonly by the use of screens. Several types of screens are in common use, including 1) Reciprocating screens for sizing shredded yard wastes; 2) Trommel screens used for preparing commingled MSW prior to shredding and; 3) disc screens used for removing glass from shredded MSW.
Density separation	Unit operations in which materials are separated by density. Typical applications include 1) Air classifiers for the preparation of RDF; 2) Inertial separation for the processing of commingled MSW; and 3) Floatation for the processing of construction debris.
Electric and Magnetic field separation	Unit operations in which materials are separated by their electrostatic charge and magnetic permeability. Typical applications include 1) the separation of plastic from paper and 2) the separation of ferrous from non ferrous materials.
Densification (Compaction)	Densification and compaction are unit operations that are used to increase the density of recovered materials to reduce transportation costs and simplify storage. Typical applications include 1) the use of baling for cardboard, paper, plastics and aluminium cans; and 2) the use of cubing and pelletizing for the production of densified RDF.
Materials handling	Unit operations used for the transport and storage of MSW and recovered materials. Typical applications include 1) conveyors for the transport of MSW and recovered materials; 2) storage bins for recovered materials; and 3) rolling stock such as forklifts, front-end loaders, and various types of trucks for the movement of MSW and recovered material.

TABLE 2-5: METHODS USED FOR THE PROCESSING AND THE RECOVERY OF INDIVIDUAL WASTE COMPONENT FROM MSW
(Source: Tchobanoglous, et, el, 1993)

physical and chemical properties, as is required for further processing operations like thermal processing or biological processing.

Every unit operation for processing the solid wastes in the developed countries is designed for either recovery of material resources or for the recovery of energy. Thus the resource and energy potential of the solid wastes is kept in mind while planning for its management, right from the point of generation to the final disposal. The various materials that have been recovered for recycling from

Municipal Solid Wastes (MSW) in developed countries are given in the Table 2-6.

RECYCLABLE MATERIAL	TYPES OF MATERIAL OR USES
Aluminium	Soft drink and beer cans
Paper	
Old newspaper	Newsstand and home delivered newspaper
Corrugated cardboard	Bulk packaging; largest single source of waste paper for recycling
High grade paper	Computer paper, white ledger paper, and trim cutting
Mixed paper	Various mixtures of clean paper, including newsprint
	Magazines, and white and coloured long fibre paper
Plastics	
Polyethylene terephthalate(PETE)	Soft drink bottles, salad dressings and vegetable oil bottles; photographic film
High density polyethylene(HDPE)	Milk jugs, water containers, detergent and cooking oil bottles
Polyvinyl chloride(PVC)	Home landscaping irrigation piping, some food packaging, and bottles
Low density polyethylene(LDPE)	Thin-film packaging and wraps; dry cleaning film bags; other film materials
Polypropylene(PP)	Closures and labels for bottles and containers, battery casings, bread and cheese wraps, cereal box liners
Polystyrene(PS)	Packaging for electronic and electrical components, foam cups, fast food containers, tableware and microwave plates
Multi-layer and other	Multi-layered packaging, ketchup and mustard bottles
Mixed plastics	Various combinations of the above products
Glass	Clear, green and brown glass bottles and containers
Ferrous metals	Tin cans, white goods and other metals
Nonferrous metals	Aluminium, copper, lead etc.
Yard wastes, collected separately	Used to prepare compost; biomass fuel; intermediate landfill cover
Organic fraction of MSW	Used to prepare compost for soil applications; compost for use as intermediate landfill cover; methane; ethanol and other organic compounds; RDF
	Soil, asphalt, concrete, wood, shingles, metals
Construction and demolition wastes	
Wood	Packing materials, pallets, scraps and used wood from construction projects
Waste oil	Automobile and truck oil; reprocessed for reuse/fuel
Tyres	Automobile and truck tyres; road building material, fuel
Lead acid batteries	Automobile batteries; shredded to recover components like acid, plastic and lead
Household batteries	Potential recovery of zinc, mercury and silver

TABLE 2-6: MATERIALS THAT HAVE BEEN RECOVERED FOR RECYCLING FROM MSW
(Source: Tchobanoglous, et el, 1993)

2.8.3 THERMAL PROCESSING

Incineration provides a means of disposing of refuse by high temperature oxidation. The primary function of incineration is that of reducing the volume of wastes. However it also serves the secondary role of energy production and destruction of putrescible or hazardous wastes.

Incineration of solid wastes leaves a residue which is approximately equal in mass to the inert content of the waste. For a typical municipal waste, approximately 20% by weight of the refuse remains as reside when complete burnout is achieved. The maximum volume reduction, due to both decrease of mass and increase of density, is about 97.5 percent. For conventional municipal incineration the volume reduction may range from 80 to 95.5 percent, with a mean of about 90 percent (***Wilson, David G., 1977***), Conventional incineration thus provides a means of extending the lives of landfill.

Although the technology of incineration has greatly advanced, the main problem in its implementation in the developed countries was the air pollution caused by the gaseous products of incineration. Since most developed countries have stringent Air Pollution Control (APC) regulations, the incinerators have to incorporate expensive equipment to keep the discharges to acceptable levels.

There are many different types of incinerators in use in the developed countries, which are designed for specific waste streams. However, the operating principles remain the same. Figure 2-3 gives the schematic diagram of an incinerator.

In the present day world of rapidly changing technologies, the process of incineration has been greatly modified and developed to suit the requirements of the waste composition, emissions and environmental considerations in the developed countries. The concept of incineration has been replaced with the wider perspective and highly evolved engineering techniques of thermal processing. In the developed countries solid wastes are now subjected to thermal processing for both volume reduction and energy recovery. Thermal processing of solid wastes leads to the conversion of solid wastes into gaseous, liquid and solid conversion products, with the concurrent or subsequent release of energy.

In the developed countries the thermal processing systems are categorized on the basis of their air requirements:

a) *Stoichiometric Combustion* - combustion with exactly the amount of oxygen (or air) needed for complete combustion.

b) *Excess-Air Combustion* - combustion with oxygen in excess of the stoichiometric requirements.

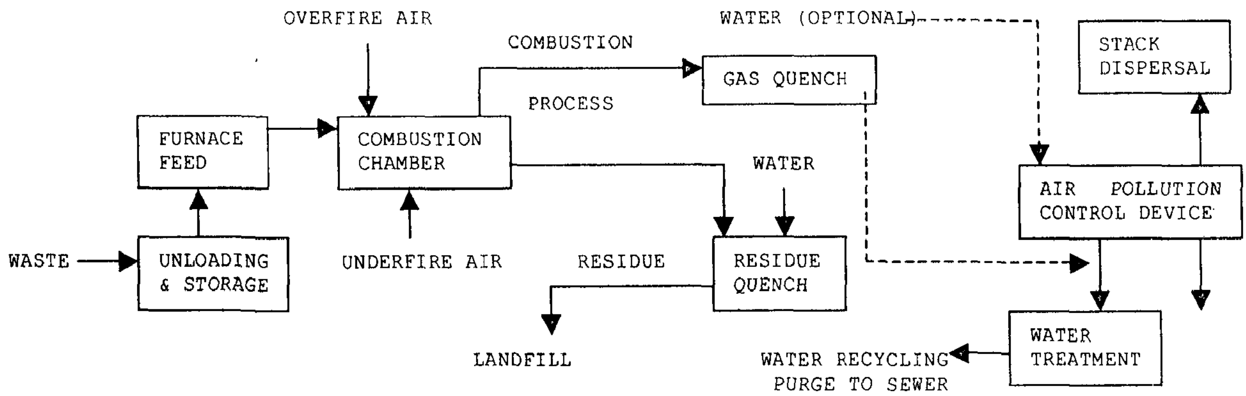


FIGURE 2-2: SCHEMATIC DIAGRAM OF AN INCINERATOR
(Source: Wilson, David G., 1977)

c) *Gasification* - is the partial combustion of solid waste under substoichiometric conditions to generate a combustible gas containing carbonmonoxide, hydrogen and gaseous hydrocarbons.

d) *Pyrolysis* is the thermal processing of waste in the complete absence of oxygen.

(Tchobanoglous, et el, 1993)

2.8.3.1 HEAT RECOVERY SYSTEMS

Almost all new solid waste combustion systems in U.S.A. and Europe employ some form of energy recovery to help offset operating costs and to reduce the capital costs of air pollution control equipment. Energy can be recovered from the hot flue gases generated by combusting MSW or RDF by the following two methods:

(a) Waterwall Combustion Chambers

In this method, the walls of the combustion chambers are lined with the boiler tubes that are arranged vertically and welded together in continuous sections. The water which is circulated through the tubes absorbs the heat generated in the combustion chamber and converts to steam

(b) Waste Heat Boiler

In this method the combustion chamber of the furnace is lined with insulating refractory materials to reduce heat losses through the furnace walls. The hot flue gases are passed through a separate waste heat boiler located externally to the combustion chamber. This method of heat recovery is commonly used in modular combustion units.

2.8.3.2 PYROLYSIS SYSTEMS

Pyrolysis is the thermal processing of solid wastes in the complete absence of air. Most organic substances being thermally unstable, can be spilt through a combination of thermal cracking and condensation, in an oxygen-free atmosphere, into gaseous, liquid and solid fractions. This is the gambit of pyrolysis. The pyrolytic process is highly endothermic.

The characteristics of the three major component fractions resulting from the pyrolysis of the organic fraction of MSW are:

a) A gas stream containing primarily hydrogen, methane, carbon monoxide, carbon dioxide and various other gases depending on the organic characteristics of the waste.

b) A tar and/or oil stream that is liquid at room temperature and contain chemicals such as acetic acid, acetone, and methanol.

c) A char consisting of pure carbon plus any inert materials that may have entered the process.

Only one full-scale MSW pyrolysis system was built in El Cajon, California, U.S.A. Named as the Occidental Flash Pyrolysis System, it failed to achieve its primary operational goal of production of a saleable pyrolysis oil and was shut down after two years of operation. The principal causes for failure of pyrolysis technology have been the inherent complexity of the systems and the lack of appreciation by system designers of the difficulties of producing a consistent feedstock from municipal solid waste ***(Tchobanoglous, et el, 1993)***.

2.8.3.3 GASIFICATION SYSTEMS

Gasification is the general term used to describe the process of partial combustion in which a fuel is deliberately combusted with less than stoichiometric air. Gasification is an energy efficient technique for reducing the volume of solid waste and the recovery of energy. Essentially the process involves partial combustion of a carbonaceous fuel to generate a combustible fuel gas rich in carbon monoxide, hydrogen and some saturated hydrocarbons, principally methane. The fuel gas can then be combusted in an internal combustion engine, gas turbine or boiler under excess-air conditions. There are many different types of gasifiers in use, however reliable results have not been achieved with mass fired gasifiers in the full-scale and pilot-scale units and as such gasification systems are not commercially viable presently. But due to their lower air emissions, as compared to the excess air combustion systems, gasifiers may hold the most potential for future development.

2.8.3.4 POLLUTION DUE TO THERMAL PROCESSING AND CONTROL MEASURES

The operation of any thermal processing system produces many adverse impacts on the environment which includes the emission of gases and particulate matter, solid residues and liquid effluents. In the developed countries stringent pollution control laws and regulations are laid down to restrict the pollution and environmental degradation due to the thermal processing systems. Thus the proper design of control systems for these emissions is an important aspect of the designing of a thermal processing system. However, all the pollution control equipment and systems are capital intensive and require constant monitoring. In some cases, the cost and complexity of the environmental control systems are equal or even more than the cost of the thermal processing system itself. Also the pollution control systems are not a gainful investment for the system owner who finds these as a drain on his resources and thus tries to meet the minimum essential emission standards in his facility. In such a situation the regulatory authorities have to be ever vigilant to prevent violation of standards. In the U.S.A. the EPA issued *Standards of Performance* for new Municipal Waste Combustors (MWC) being installed and *Emission Guidelines* for existing MWC under the authority of Clean Air Act in 1991. Some of the states in the U.S.A. have implemented even stricter standards than that stipulated by the EPA.

In the U.S.A. the relationships between the various concentrations of air pollutants and their adverse effect on humans and the environment was studied and analysed by the Environmental Protection Agency (EPA) and this information was used to develop a list of ***criteria pollutants*** and acceptable ambient levels. These levels are known as the National Ambient Air Quality Standards and all thermal processing units are strictly monitored for compliance of these standards. Some of the criteria pollutants identified include carbon monoxide, sulphur dioxide, nitrogen dioxide, ozone, inhalable particulate matter and lead. In addition to these criteria pollutants the EPA has also identified ***noncriteria pollutants*** like cadmium (Cd), chromium (Cr), mercury (Hg), acid gases like hydrogen fluoride (HF) and hydrogen chloride (HCl), and dioxins.

2.8.4 BIOLOGICAL PROCESSING

Other than plastic, rubber and leather components the organic fraction of MSW can be considered to be composed of proteins, amino acids, lipids, carbohydrates, cellulose, lignin and ash. This organic fraction of MSW may be subjected to biological processing to reduce the volume and weight of the materials to produce compost, a humus like material that can be used as a soil conditioner and to produce methane.

The biological transformation may be accomplished either aerobically (in the presence of oxygen) or anaerobically (in the absence of oxygen. The end product in each case is different. The different types of biological process that are used for conversion of organic fraction of MSW are discussed in the following sections.

2.8.4.1 AEROBIC COMPOSTING

Aerobic composting involves the activity of aerobic microbes and hence the provision of oxygen during the composting process. Aerobic composting is characterized by high temperatures, the absence of foul odours and is more rapid. Under controlled conditions, the organic fraction of MSW can be converted to compost. The principal end products are new cells, compost, carbon dioxide, water, ammonia and sulphates. Compost usually contains a high percentage of lignin which is difficult to convert biologically in a relatively short time. The aerobic composting process is carried out by the naturally occurring micro-organisms which will spontaneously grow in any mixed natural organic waste if it is kept moist and aerated. The growth of these organisms, which initially are predominantly bacteria, liberates heat, CO_2 and water vapour. If heat is generated faster than it can escape, the temperature will rise killing the heat sensitive organisms and facilitating the growth of heat tolerant bacteria. In the first stage, mesophilic bacteria (the bacteria which are heat sensitive) as well as actinomycetes, yeasts and other fungi break down fats, proteins and carbohydrates. Protozoa prey on the bacteria and fungi. As the temperature reaches the range of 40-50°C, nearly all the organisms that initiated the composting action are killed and their place is taken by a more limited series of thermophilic bacteria (the bacteria which are tolerant to heat) which can grow and produce heat up to a temperature of 70°C. in that part of the compost that reaches 60-70°C, essentially all pathogenic organisms, except for a few spores, are killed in a few hours. When the thermophilic bacteria have exhausted the food available to them, they stop producing heat and the compost cools off. In the cooling compost, a new series of organisms, dominated by fungi and actinomycetes, grows on the residual food, including dead bacteria, giving the compost its final properties. The three stages of composting may be referred to as the initial mesophilic stage, the thermophilic stage and the curing stage. The end product of composting is a mass of organic material composed of indigestible residues closely resembling the humus that is made naturally in the soil from plant and animal residues by similar biological processes. Ammonia, which is toxic to germinating seeds, is produced in the first two stages and is removed in the curing stage ***(Suess, Michael J., 1985)***.

2.8.4.2 ANAEROBIC DIGESTION

The biodegradable portion of the organic fraction of MSW can be converted biologically under anaerobic conditions to a gas containing carbon dioxide and methane. Anaerobic decomposition is characterized by low temperature, the production of odorous intermediate products, and it generally proceeds at a slower rate than aerobic decomposition. The principal end products are carbon dioxide, methane, ammonia, hydrogen sulphide and resistant organic matter. The resistant organic matter must be dewatered, before it can be disposed off by landfilling or land spreading. The biological conversion of the organic fraction of municipal solid waste under anaerobic conditions is thought to occur in three steps. The first step in the process involves the enzyme-mediated transformation (hydrolysis) of higher-molecular-mass compounds into compounds suitable for use as a source of energy and cell tissue. The second step involves the bacterial conversion of the compounds resulting from the first step into identifiable lower-molecular-mass intermediate compounds. The third step involves the bacterial conversion of the intermediate compounds into simpler end products, principally methane and carbon dioxide.

In the anaerobic decomposition of wastes, a number of anaerobic organisms work together to bring about the conversion of organic portion of the wastes to a stable end product. One group of organisms is responsible for hydrolysing organic polymers and lipids to basic structural building blocks such as fatty acids, monosaccharides, amino acids, and related compounds. A second group of anaerobic bacteria ferments the breakdown products from the first group to simple organic acids, the most common of which in anaerobic digestion is acetic acid. This second group of microorganisms, described as non-methanogenic, consists of anaerobic bacteria that are often identified in the literature as "acidogens" or "acid formers."

A third group of microorganisms converts the hydrogen and acetic acid formed by the acid formers to methane gas and carbon dioxide. The bacteria responsible for this conversion, are strict anaerobes, called methanogenic, and are identified in the literature as "methanogens" or "methane formers." Many of the methanogenic organisms identified in landfills and anaerobic digesters are similar to those found in the stomachs of ruminant animals and in organic sediments taken from lakes and river. The most important bacteria of the methanogenic group are the ones that utilize hydrogen and acetic acid. They have very slow growth rates and as a result their metabolism is usually considered rate limiting in the anaerobic treatment of organic wastes. Waste stabilization in anaerobic digestion is accomplished when methane and carbon dioxide are produced. Methane gas is highly insoluble and its departure from a landfill or solution represents actual waste stabilization.

Presently there is a great interest in the developed countries in applying the anaerobic digestion process for the processing of organic fraction of the MSW due to the opportunity to recover methane and the fact that the digested material is similar to the compost produced aerobically. Some of the common anaerobic digestion technologies for MSW and yard wastes currently under development or in use in the developed countries are given in the Table 2-8.

TECHNOLOGY LEVEL	PROCESS DESCRIPTION
Bangalore (Indore)	Trench in ground; 2 to 3 ft. deep. Material placed in alternate layers of refuse, night soil, earth, straw, etc. no grinding. Turned by hand as often as possible. Detention time of 120 to 180 days.
Casperi (Briquetting)	Ground material (waste) is compressed into blocks and stacked for 30 to 40 days. Aeration by natural diffusion and air flow through stacks. Curing follows initial composting. Blocks are later ground.
DANO (Biostabiliser)	Rotating drum, slightly inclined from the horizontal, 9 ft. to 12 ft. in diameter; up to 150 ft. long. One to 5 days digestion followed by windrowing. No grinding. Forced aeration into drum.
Earp-Thomas	Silo type with 8 decks stacked vertically. Ground waste is moved downward from deck to deck by ploughs. Air passes downward through the silo. Uses a patented inoculum. Digestion 2 to 3 days followed by windrowing.
Fairfield-Hardy	Circular tank. Vertical screws, mounted on two rotating radial arms, keep ground material agitated. Forced aeration through tank bottom and holes in screws. Detention time of 5 days.
Frazer-Eweson	Ground waste placed in vertical bin having 4 or 5 perforated decks and special arms to force composting material through perforations. Air is forced through bin. Detention time of 4 to 5 days.
Jersey (also known as John Thompson system)	Structure with 6 floors, each equipped to dump ;ground waste onto the next lower floor. Aeration effected by dropping from floor to floor. Detention time of 6 days.
Metrowaste	Open tanks, 20 ft. wide by 10 ft. deep by 200 ft to 400 ft. long. Processed MSW shredded in pretreatment processing. Equipped to give

TECHNOLOGY LEVEL	PROCESS DESCRIPTION
	one or two turnings during digestion period (7days). Air is forced through perforations in bottom of tank.
Naturizer or International	Five 9 ft. wide steel conveyer belts arranged to pass material from belt to belt. Each belt is an insulated cell. Air passes through digester. Detention time of 5 days.
Riker	Four-story bins with clamshell floors. Ground waste is dropped from floor to floor. Forced air aeration. Detention time of 20 to 28 days.
Ashbrook- Simon-Hartley	Tunnel reactor typically 18 ft. wide by 12 ft. high by 65 ft. long. Plug flow with wastes pushed into and out of reactor. Pressure and vacuum blowers used to supply and exhaust air through air diffusers located in floor of reactor. Detention time of 18 to 20 days.
T.A. Crane	Two cells consisting of 3 horizontal decks. Horizontal ribbon screws extending the length of each deck recirculate ground waste from deck to deck. Air is introduced in bottom of cells. Composting followed by curing in a bin.
Tollemache	Similar to the metrowaste digesters.
Triga	Towers or silos called "hygienisators." In sets of 4 towers. Waste is ground. Forced air aeration. Detention time of 4 days.
Windrowing(normal, *aerobic process)*	Open windrows, with a "haystack" cross-section. Waste is ground. *Aeration by turning windrows. Detention time depends upon number of* turnings and other factors.
Van Maanen process	Underground waste in open piles, 120 to 180 days.

TABLE 2-7: REPRESENTATIVE COMPOSTING TECHNOLOGIES FOR MSW AND YARD WASTE.
(Source: Tchobanoglous, et el, 1993)

2.9 DISPOSAL OF SOLID WASTES AND RESIDUES

The safe and reliable long-tern disposal of solid waste residues is an important component of waste management. Solid waste residues are waste components that are not recycled, that remain after processing at a materials recovery facility (MRF), or that remain after the recovery of conversion products and/energy.

In 1968, the United States Public Health Service (USPHS) conducted a survey of more than 6000 land disposal site and it was found that only 6% of all sites surveyed satisfied all three criteria of adequate daily cover, no open burning and no water pollution from leachates. Strict regulations and pollution control measures were implemented thereafter to reduce the menace of pollution and degradation of the atmosphere. ***(Hagerty, Joseph D., et el., 1973)***

One of the oldest method of disposal of solid wastes practised by man is that of landfilling. Until a few decades back there had been no real modification in the practice of disposal by open dumping except for burning of the wastes in the open dump. With greater understanding of the process of combustion, it has been realized that burning of an open dump leads to pollution of air and thus, the land pollution is traded with air pollution. Thus the practice of disposal of solid wastes in a landfill has been modified to minimize environmental pollution. The modified practice is referred to as sanitary landfilling.

Sanitary landfilling is defined by the American Society of Civil Engineering as "a method of disposing of refuse on land without creating nuisance of hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each days operation, or at such more frequent intervals as may be necessary"(***Hagerty,Joseph D., et el,1973***).

The principles of sound landfill management are based on four main criteria (***David, C. Wilson, 1981***) as given below:

(a) Environmental nuisances such as odours, fires vermin, insects, birds, windblown litter and visual intrusion should be eliminated or at least kept to a minimum.

(b) The available void space in the site should be utilized to the full be ensuring good compaction of the waste.

(c) Problems of water pollution and gas generation should be minimized.

(d) The management of site should reflect the after-use for which the reclaimed land is intended.

The sanitary landfill, thus is an engineered construction. Four basic steps should be considered in that construction (***Hagerty, D. Joseph, et el,1973***):

(a) The deposition of solid waste in a prepared section of a site in such a way that the working face has a minimum area.

(b) The spreading and compaction of the waste in thin layers.

(c) The covering of the waste with a layer of compacted cover soil either daily or more frequently if required.

(d) The final cover of the entire construction with a compacted earth layer 2 to 3 feet thick.

The foremost concern of a landfill planner is the possibility of contaminates (or pollutants) generated within the fill during the decomposition of the contained refuse entering the surrounding environment and prove hazardous to any life form with which it may come in contact.

The contaminants from a landfill can enter the surrounding environment only if those contaminants are transported in some way from within the landfill to the environment. One of the major sources of transport for contaminants is water, which seeps or percolates through the fill and enters either ground-water system or the surface water. Another source of transportation may arise from the contaminant itself i.e. gases which are generated within a landfill as a result of degradation of organic materials may move as a result of the pressure and increased concentration. Therefore considerable attention should be given to the topography of a site, hydrology of the area both with respect to surface and groundwater and the overall geology of the site including the characteristics of both soil and rocks there (***Hagerty, Joseph D., et el, 1973***).

2.9.1 LANDFILL PLANNING, DESIGN AND OPERATION

The principle elements that must be considered in the planning, design and operation of landfill are:

(a) landfill layout and design

(b) landfill operations and management

(c) the reactions occurring in landfills

(d) the management of landfill gases

(e) the management of leachate

(f) environmental monitoring and

(g) landfill closure and postclosure care

Figure 2-8 below gives the definition sketch of landfill operations and processes.

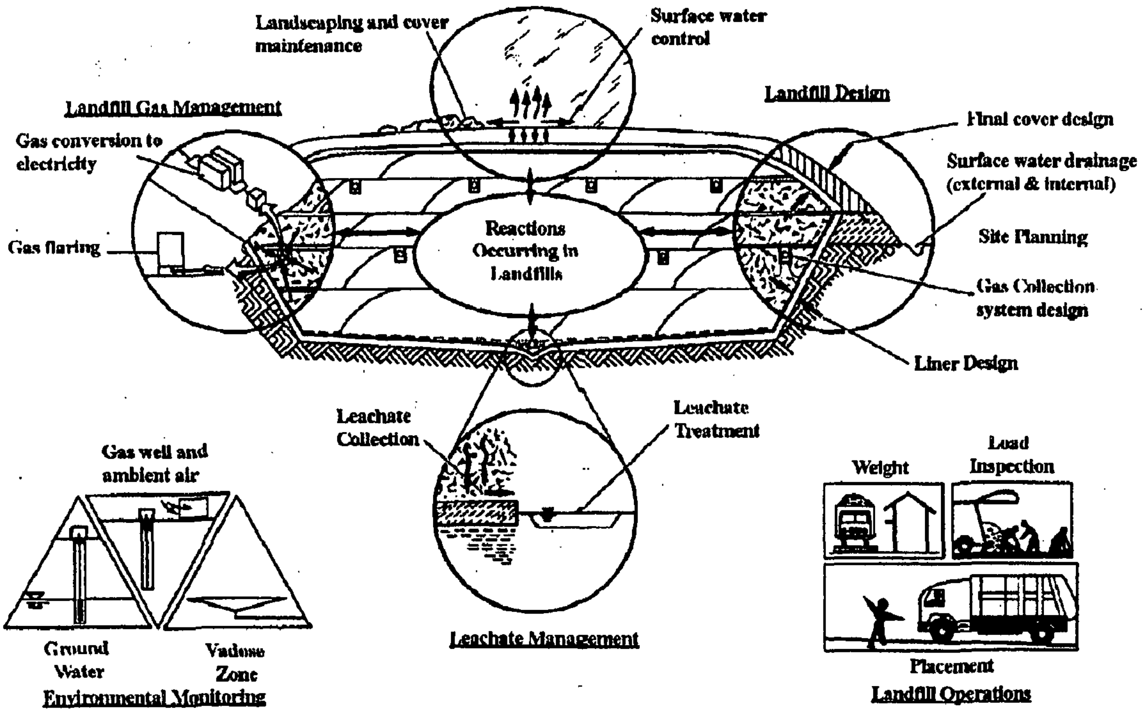


FIGURE 2-8: DEFINITION SKETCH FOR LANDFILL OPERATAIONS AND PROCESSES
(Source: Tchobanoglous, et el, 1993)

2.9.2 DEVELOPMENT OF SITE FOR LANDFILLING

The first step in the development of a landfill site is the preparation of the site, which involves the following:

(a) Modification of existing site drainage to divert any runoff away from the intended landfill area.

(b) Construction of access roads.

(c) Provision of weighing facilities.

(d) Installation of fences around the site.

The next step in the development of a landfill involves the excavation and preparation of the landfill bottom and subsurface sides. In the developed countries the landfills are constructed in sections thereby allowing only a small part of the unprotected landfill surface to be exposed to precipitation at any time. Also the excavations are carried out over time, rather than preparing the entire landfill bottom at once.

In any landfill it is desirable to obtain the cover materials from the site itself, basically to minimise the costs. Due to this consideration the initial working area of the landfill is excavated to the design depth and the excavated material is stockpiled for later use as cover material. The equipment to be used for monitoring the *Vadose* zone (zone between ground surface and permanent groundwater) and groundwater is installed before the landfill liner is laid. The landfill bottom is shaped to provide drainage of leachate, and a low-permeability liner is installed. Leachate collection and extraction facilities are placed within or on top of the liner. The liner extends up the excavated walls of the landfill. Horizontal gas recovery trenches are generally placed at the bottom of the landfill.

Once the landfill site has been prepared, the next step in the process involves the actual placement of waste material. As shown in Figure 2-9, the waste is placed in cells beginning along the compaction face, continuing outward and upward from the face. The waste deposited in each operating period, usually one day, forms an individual cell. Wastes deposited by the collection and transfer vehicles are spread out in 18- to 24-in layers and compacted. Typical cell heights vary from 8 to 12 ft. The length of the working face varies with the site conditions and the size of the operation. The working *face* is the area of a landfill where solid waste is being unloaded, placed and compacted during a given operating period. The width of a cell varies from 10 to 30 ft, again depending on the design and capacity of the landfill. All exposed faces of the cell are covered with a thin layer of soil (6 to 12 in) or other suitable material at the end of each operating period.

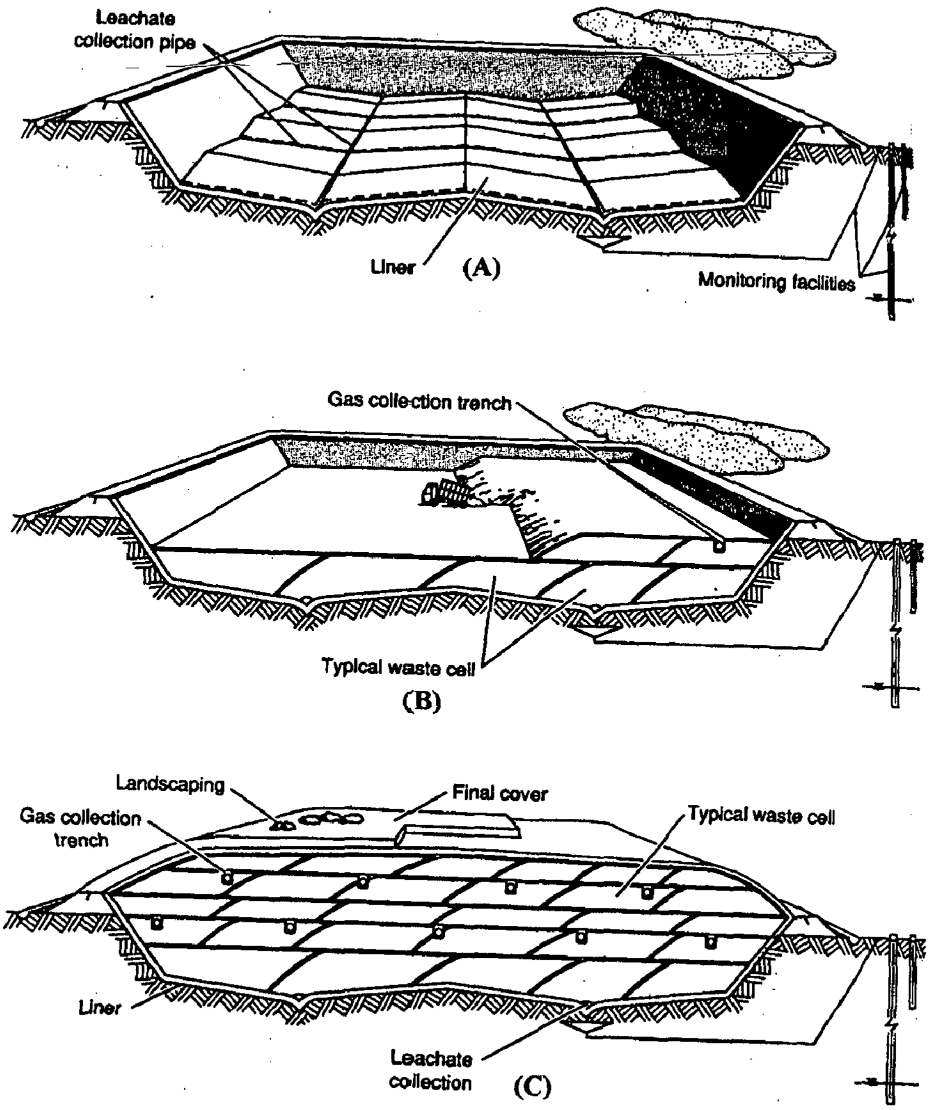


FIGURE 2-9: DEVELOPMENT AND COMPLETION OF A LANDFILL; (A) EXCAVATION AND INSTALLATION OF LANDFILL LINER, (B) PLACEMENT OF SOLID WASTE IN LANDFILL, AND (C) SECTION THROUGH COMPLETED LANDFILL

(Source: Tchobanoglous, et el, 1993)

After one or more lifts have been placed, horizontal gas recovery trenches can be excavated in the completed surface. The excavated trenches are filled with gravel, and perforated plastic pipes are installed in the trenches. Landfill gas is extracted through the pipes as the gas is produced. Successive lifts are placed on top of one another until the final design grade is reached. Depending on the depth of the landfill, additional leachate collection facilities may be placed in successive lifts. A cover layer is applied to the completed landfill section. The final cover is designed to minimize infiltration of precipitation and to route drainage away from the active section of the landfill. The cover is landscaped to control erosion. Vertical gas extraction wells may be installed at this time through the completed landfill surface. The gas extraction system is tied together and the extracted gas may be flared or routed to energy recovery facilities as appropriate.

Additional sections of the landfill are constructed outward from the completed sections, repeating the construction steps outlined above. As organic materials deposited within the landfill decompose, completed sections may settle. Landfill construction activities must include refilling and repairing of settled landfill surfaces to maintain the desired final grade and drainage. The gas and leachate control systems also must be extended and maintained. Upon completion of all fill activities, the landfill surface is repaired and upgraded with the installation of a final cover. The site is then landscaped appropriately and prepared for other uses.

2.9.3 SOLID WASTE MANAGEMENT IN PRACTICE

Recent concepts of Solid Waste Management in the developed countries are based on the hierarchy of principles based on the four Rs-Reduction, Reuse, Recycling and Recovery. With respect to MSW landfill site should be considered only for those wastes or fractions that are no further recoverable.

Table 2-10 gives the details of the disposal methods used for the solid wastes in some of the European countries. From the table it is evident that most of the European countries resort to use of disposal methods other than landfilling. The main reasons for the shift towards disposal methods other than landfilling is the realization of the dangers to the environment due to indiscriminate landfilling, lack of land for indefinite landfilling in the countries with small land mass and the need to optimize the recovery of energy and materials from the solid wastes, which would otherwise be lost if landfilled. The most important aspect however, remains the cost effect benefits of other methods viz a viz landfilling for most land starved countries. The table below gives the percentage of solid wastes disposed by each disposal method.

COUNTRIES	LANDFILLING	INCINERATION	COMPOSTING	RECYCLING
Austria	55	12	17	16
France	44	41	9	6
Germany	47	19	-	34
Greece	94	1	-	5
Hungary	87	9	-	4
Italy	90	6	-	4
Netherlands	50	17	-	33
Spain	76	4	10	10
Sweden	36	49	5	10
Switzerland	14	47	-	39
U.K.	90	8	-	2

TABLE 2-8: DISPOSAL PRACTICE IN SOME EUROPEAN COUNTRIES (Source: International Directory of Solid Waste Management, 1998-99, The ISWA Yearbook)

2.10 LEGISLATIVE ASPECTS OF SWM IN DEVELOPED COUNTRIES

The environmental ethics are more evolved in the developed countries and are an integral facet of economic planning and national commitment. The environmental legislation in the developed countries has exerted a tremendous impact upon private, governmental and industrial sectors of the community. These laws have also placed economic restrictions on many municipal and industrial operations.

In addition to general environmental laws there are specific laws that pertain to solid wastes alone.

In the U.S.A. the Solid Waste Disposal Act, 1965 was the enacted in 1965. The Act lays down regulations governing every aspect of SWM. The United States Public Health Service (USPHS) is responsible for enforcing this act.

The National Environmental Policy Act (NEPA), 1965 is an all encompassing law. It affects all projects that have some federal funding or that come under the regulation of federal agencies. The act specified the creation of the Council of Environmental Quality in the office of the President. This body has the authority to force every federal agency to submit to the council and Environmental Impact Statement (EIS) on every activity of project that it sponsors or over which it has jurisdiction. (***Tchobanoglons, et el, 1993***)

Some other legislations connected to solid wastes management are:

(a) Resource Recovery Act 1970

(b) Resource Conversation and Recovery Act 1976

Legislation is an important part of SWM in the developed countries. Thus only government mandated solid waste programmes created by legislation, including standards and mandates for facilities, is an accepted practice. Many agencies in the developed countries are involved in gathering data on environmental impacts of waste management practices and studying ways to improve future practices.

2.11 MANAGEMENT OF MUNICIPAL HAZARDOUS WASTES IN DEVELOPED COUNTRIES

Hazardous wastes have been defined as wastes or combination of wastes that pose a substantial present or potential hazard to humans or other living organisms because of the following reasons:

(a) such wastes are non-degradable or persistent in nature,

(b) they can be biologically magnified,

(c) they can be lethal,

(d) they can otherwise cause or tend to cause detrimental cumulative effects.

Wastes are categorised as hazardous based on their properties that are related to safety and health of humans and other living organisms. Some of the properties that are used to categorise wastes as hazardous are:

(a) *Safety related properties*

- (i) Corrosivity
- (ii) Explosivity
- (iii) Flammability
- (iv) Ignitability
- (v) Reactivity

(b) *Health related properties*

- (i) Carcinogenicity
- (ii) Infectivity
- (iii) Irritant(allergic response)
- (iv) Mutagenicity
- (v) Toxicity(poisons)
- (vi) Radioactivity
- (vii) Teratogenicity

Many of the products used within the households everyday such as paint products, automotive products, household cleaners, aerosols are toxic and are hazardous for human health and the environment. Some of the common hazardous household products and their common disposal methods in the developed countries are given in the table below:

Product	Concern	Disposal
Household cleaners		
Abrasive scouring powders	Corrosive	Hazardous waste facility
Aerosols	Inflammable	Hazardous waste facility
Ammonia and ammonia based cleaners	Corrosive	Hazardous waste facility Or dilute small amounts
Chlorine bleach	Corrosive	Hazardous waste facility Or dilute small amounts
Drain openers	Corrosive	Hazardous waste facility
Furniture polish	Inflammable	Hazardous waste facility
Glass cleaners	Irritant	Dilute small amounts
Outdated medicines	Hazardous	Dilute small amounts
Oven cleaner	Corrosive	Hazardous waste facility
Shoe polish	Inflammable	Hazardous waste facility
Silver polish	Inflammable	Hazardous waste facility
Spot remover	Inflammable	Hazardous waste facility
Toilet bowl cleaner	Corrosive	Hazardous waste facility
Upholstery and carpet cleaner	Inflammable/ corrosive	Hazardous waste facility
Personal care products	Poison	Dilute small amounts and flush down toilets
Hair waving lotions	Poison	-do-
Medicated shampoos	Poison, Inflammable	Hazardous waste facility
Nail polish remover	Poison	Hazardous waste facility
Rubbing alcohol	Poison	Hazardous waste facility
	Inflammable	Hazardous waste facility
Automotive products		
Antifreeze	Corrosive	Recycling centre/repair
Brake and transmission fluid	Inflammable	Recycling centre
Car batteries		Recycling centre
Diesel fuel	Inflammable	Hazardous waste facility
Kerosene	Inflammable	Recycling centre
Gasoline	Inflammable	Donate or hazardous waste facility
Waste oil	Inflammable	
Paint products		
Enamel, oil-based, latex or water-based paints	Inflammable	Reuse or hazardous waste facility
Paint solvents and thinners		
Miscellaneous products	Corrosive	Recycling centre or hazardous waste facility
Batteries		

Product	Concern	Disposal
Photographic chemicals	Corrosive, poison	Hazardous waste facility
Acids and chlorine	Corrosive	Hazardous waste facility
Pesticides, herbicides and fertilizers	Poison	Hazardous waste facility
Chemical fertilizers	Poison	Hazardous waste facility
Houseplant insecticides	Poison	

TABLE 2-9: COMMON HOUSEHOLD HAZARDOUS WASTES
(Source: Tchobanoglous, et el, 1993)

The small amounts of hazardous wastes found in the MSW are of significance because of their occurrence in all solid waste management facilities and their persistence when discharged to the environment. The occurrence of these hazardous wastes in MSW also influences the recovery of materials, conversion products like compost, combustion products and landfills. Even trace amounts of hazardous organic constituents found in the conversion products render the materials and products unusable. Thus source separation is being encouraged in the developed countries to eliminate these constituents from solid waste processing operations. Trace organic hazardous constituents have also been found in the atmosphere near the landfills, in the extracted landfill gases and in the landfill leachate. Thus it becomes essential to identify and deal with the hazardous constituents of the MSW in a comprehensive manner. However in this report the various methods of processing and treating the hazardous wastes have not been dealt with due to limitation of the scope of the dissertation.

2.12 INFERENCES FROM THE STUDY OF SOLID WASTE MANAGEMENT PRACTICES IN DEVELOPED COUNTRIES

For a clean environment and sustained aesthetic appeal of a city it is pertinent to manage the solid wastes in an organized and planned manner. In the developed countries we find a deliberate effort not only by the Urban Local Bodies but also by the communities to participate and contribute in a positive manner in the process of Solid Waste Management. The greater consciousness and awareness in the population in the context of health and environmental issues has facilitated the formulation of regulations, guidelines and policies governing every aspect of SWM.

From the study of SWM practices in developed countries there are many important lessons to be learnt and many aspects of SWM for emulation and adoption into our own SWM practices. Some of the important lessons that are forthcoming from aforementioned studies are:

1. Solid Waste Management Systems require well-planned management, institutional and financial systems to support the equipment and facilities infrastructure.

2. There is a requirement of technical expertise for executing the SWM activities.

3. The gambit of SWM includes the management/regulation of waste generating activities aimed at reduction of waste generation by formalisation of reuse, recycling and recovery of materials and energy.

4. The optimum use of available and appropriate technologies should be adopted for managing the different types of wastes.

5. The solid waste management systems should be regulated by stringent legislations that are strictly enforced.

6. The functional elements of SWM should be integrated and fine tuned to be best adapted and integrated as per the requirements of the community/city.

7. The use of various options for processing and treatment should not only be based on the availability but also on the objectives of the management system.

8. The type of wastes being generated should dictate the objectives of the SWM system and the use of various technologies for processing and treatment of the waste.

CHAPTER 3

SOLID WASTE MANAGEMENT PRACTICES IN INDIA

3.1 GENERAL

SWM is an obligatory function of the Urban Local Bodies (ULBs) in India as per the Municipal Solid Wastes (Management and Handling) Rules 2000. However, this service is poorly performed, resulting in problems of health, sanitation and environmental degradation. With high annual growth rate of population (over 3.6%) the situation is fast deteriorating. The poor financial health of the ULBs does not permit the infrastructure development to match the pace of population growth. In such a scenario, the SWM in urban areas is the most affected amongst the essential services. As per the Report of the Committee constituted by the Hon. Supreme Court of India', March'99, the lack of financial resources, inefficient institutional arrangements, inappropriate technology, weak legislative measures and public apathy towards SWM has made the service most unsatisfactory and the public health situation untenable.

The SWM practices in India are highly deficient, using obsolete technologies, if at all, for storage, collection, processing, treatment and disposal. Throwing solid wastes on streets, roads, footpaths, drains, water bodies and open lots is a common evil that fails to even evoke a response from public and administration alike.

The resource potential of solid wastes not withstanding there is no formally organized system of segregation of solid wastes at source. The recovery and recycling of potential materials is undertaken by the informal sector of scavengers and scrap dealers. More often than not the process is unhealthy and hazardous for both, the people involved and the environment.

3.2 GENERATION OF SOLID WASTES IN INDIAN CITIES

In most Indian cities there is no system of weighing the solid wastes being collected. Estimates of the quantity of solid wastes are made on the basis of the estimated volume of wastes ***(Report of the Committee constituted by the Hon. Supreme Court of India, March 1999)***. Thus there is no accurate or measured data available on the quantities of solid wastes being actually generated in the Indian cities.

The per capita solid waste generation rates in some of the Indian cities are given in table 3-1 below. Studies conducted by numerous agencies have shown that the waste generation rates in the smaller cities are lesser than that in the larger cities.

City	WASTE GENERATION RATES (KG PER CAPITA PER DAY)
Delhi	0.60
Bangalore	0.53
Calcutta	0.51
Hyderabad	0.35

TABLE 3-1: PER CAPITA WASTE GENERATION RATES IN VARIOUS CITIES
(Source: Report of the National Commission on Urbanisation, Vol.IV, 1988)

As per the report of the Committee constituted by the Hon. Supreme Court of India, Solid Waste Management in Class I Cities in India, March 1999, cities having lesser populations have considerably lower rates of per capita generation of solid wastes, as given in table 3-2.

Population range (in Lakhs)	Average per capita waste generation (grams/capita/day)
1 to 5	210
5 to 10	250
10 to 20	270
20 to 50	350
50 +	500

TABLE 3-2: PER CAPITA WASTE GENERATION RATES IN INDIAN CITIES
(Source: Report of the Committee constituted by the Hon. Supreme Court of India, March 1999)

The solid waste generation rates are also dependent on the economic status of the population. The higher income groups generate more solid wastes than the middle and lower income groups. As per a study by the Tata Energy Research Institute (TERI), New Delhi, the lower income groups of New Delhi generate less than one-third of solid wastes than their higher income counter-parts and significantly, the composition of the solid wastes generated by the lower income groups is also different from that of the higher income groups. Table 3-3 gives the generation rates and composition of the wastes generated by the higher and low-income groups. Even in the other Indian cities a difference in generation rates is observed for the different economic groups and it would be in order to presume that it is a general phenomenon in all the cities where a high rate of consumption is directly related to a high rate of waste generation.

GENERATION CHARACTERISTICS	LOW INCOME GROUPS (LESSER THAN Rs.2000/- PER MONTH)	HIGHER INCOME GROUPS (MORE THAN Rs.8000/- PER MONTH)
PER CAPITA PER DAY	170 GRAMS	540 GRAMS
ORGANIC MATTER	65-71%	79-84%
GLASS	2.9%	0.85-2.2%
PAPER	4.8%	6.3-9.0%
PLASTIC	4.1%	7.1-8.65%
GRIT	13%	NIL

TABLE 3-3: QUANTITY AND COMPOSITION OF SOLID WASTES GENERATED BY DIFFERENT INCOME GROUP HOUSEHOLDS IN DELHI (Source: Data collected and analyzed by Tata Energy Research Institute [TERI] in January 1996)

3.3 ONSITE HANDLING, STORAGE AND PROCESSING OF SOLID WASTES IN INDIAN CITIES

The Municipalities' Acts of most Indian cities are silent on the issue of onsite storage of solid wastes at the generation points. In the absence of any regulating legislation/laws the onsite storage of solid wastes is dependent on the whims and fancies of the generator, including commercial, institutional and household premises. In Indian cities it is a common practice to throw the wastes onto roadsides, open drains and even manholes when the generator is unable to store the wastes within his premises.

In the present day SWM scenario where the recovery of energy and materials from the solid wastes is fast becoming the primary objective of SWM it is pertinent to evolve appropriate onsite storage systems for all sources of wastes, which is integrated with the collection process and facilitates the objectives of the SWM programme.

The Municipal Solid Wastes (Management and Handling) Rules, 2000, prohibits the littering of solid wastes and also lays down recycling and reuse as an important objective of SWM, but it does not deal with the requirements of onsite storage of solid wastes at various generation points. However the rules do specify that the wastes shall be collected from door-to-door and transferred to the communal storage, a system that necessitates the regularisation of onsite storage sytems. However the issue of onsite storage requires much detailed study and strict controls need to be laid down to regulate this essential functional element of SWM.

3.4 COLLECTION OF SOLID WASTES IN INDIAN CITIES

Only a few Indians cities have an organized solid wastes collection system. Most others have none. The municipality administered collection system is erratic, unreliable and inefficient and is mainly aimed at clearing large heaps of wastes from roads, streets and open spaces only when it becomes a public nuisance and poses serious threat to public health.

In most Indian cities large metal bins and concrete bins in addition to open sites are used for the temporary storage of large quantities of waste. More often than not the wastes are littered all around the bins creating an unhealthy atmosphere along with malodour.

These bins are frequented by rag pickers, scavengers as well as animals, thus posing a serious health threat to them. In addition to the health threat the scavenging activities of humans and animals lead to littering of wastes around the bins and makes the task of collection further difficult. The waste is collected periodically from these bins and transported to the disposal sites by municipal vehicles. The clearing and removal of wastes from these large bins necessitate multiple handling of the wastes. Multiple handling is unhygienic and hazardous for the workers, in the absence of protective clothing and masks as well as proper tools and implements and is one of the primary reasons for low collection efficiency. The collection efficiency of solid wastes in few selected Indian cities is given in the Table 3-4.

CITY	WASTE GENERATED (TONNES/DAY)	WASTE COLLECTED (TONNES/DAY)	COLLECTION EFFICIENCY(%)	RANK
Calcutta	3500	3150	90.00	1
Mumbai	5800	5000	86.20	2
Bangalore	2130	1800	84.50	3
Chennai	2675	2140	80.00	4
Ahmedabad	1500	1200	80.00	5
Surat	1250	1000	80.00	6
Lucknow	1500	1000	66.66	7
Delhi	3880	2420	62.37	8
Patna	1000	300	30	9

TABLE 3-4: COLLECTION EFFICIENCY OF SOLID WASTES IN SELECTED INDIAN CITIES.
(Source: National Institute of Urban Affairs (NIUA), 1997, Financing Urban Infrastructure in India, New Delhi)

The low collection efficiency in most of the Indian cities is reflective of the malaise of improper management and inadequate planning measures by the Urban Local Bodies/agencies responsible for the Solid Waste Management (SWM) in the cities.

3.5 TRANSPORTATION OF SOLID WASTES IN INDIAN CITIES

The transportation of wastes is one of the most ad-hoc among the SWM practices in India. Right from handcarts, bullock carts, three wheelers, open tractors and trucks every possible means is unscrupulously employed with scant consideration to the environment and the public health. Very few cities have suitably modified transport vehicles for transportation of solid wastes including hazardous solid wastes from industries and hospitals. Above all the transportation system is not synchronized with the collection and storage systems resulting in multiple manual handling of waste. Some of the larger cities also have modern vehicles with hydraulic lifting mechanism and in-built compactors. However, in most cities the fleet of vehicles is used only in one shift, although the number of vehicles is inadequate and the efficiency of the vehicles is severely reduced due to the improper and inefficient maintenance arrangements. In the absence of proper collection vehicles that are suited to the particular requirements of solid waste collection, the collection efficiency is reduced leading to a multitude of problems.

3.6 TREATMENT AND PROCESSING OF SOLID WASTES IN INDIA

The treatment, processing and disposal of solid wastes in Indian cities pose a rather different problem than those in developed or industrialized countries. This is attributed to the differences in generation rates, composition, physical characteristics and densities of the solid wastes as discussed in tables 2-1 and 2-2. The composition of the waste in some of the Indian cities is given in Table 3-5.

The comparative study of the solid wastes' composition for cities in industrialized countries and Indian cities reveals that ***the organic***

matter in Indian solid wastes is higher, due to the presence of a large percentage of vegetative/putrescible matter. This is attributed to the fact that Indians eat fresh vegetables and fruits in contrast to the consumption of tinned/pre-cooked food in developed countries.

Component % by wet weight	Ahmedabad	Bangalore	Bombay	Calcutta	Delhi	Kanpur
Paper and Card	5.15	1.5	3.20	0.14	5.88	1.35
Metals	0.80	0.1	0.13	0.66	0.59	0.18
Glass	0.93	0.2	0.52	0.24	0.31	0.38
Textiles	4.08	3.1	3.26	0.28	3.56	1.57
Plastics,Leather and Rubber	0.69	0.9	-	1.54	1.46	0.66
Wooden matter, Hay and Straw	1.5	0.2	17.57	-	0.42	1.0
Bones etc.	0.12	0.1	0.5	0.42	1.14	0.21
Stones etc.	8.77	6.9	-	16.56	5.98	18.38
Fine earth, ash etc.	29.01	12.0	15.45	33.58	22.95	22.93
Fermentable	48.95	75.0	59.37	46.58	57.71	53.34
Density of Refuse(Kg/cu.m	-	578	-	600	-	500

TABLE 3-5: PHYSICAL ANALYSIS OF INDIAN CITY REFUSE
(Source: Nath, K.J., 1984)

From table 3-5 we know that the composition of the solid waste in Indian cities makes it unsuitable for processing operations like incineration, pyrolysis, etc. due to the high percentage of non-combustibles and moisture in the waste. However, the high percentage of organic portion in the Indian waste makes it amenable to biological processes like composting.

In some of the large Indian cities composting of Municipal Solid Wastes (MSW) has been taken up on a commercial scale. In Faridabad (Haryana) and Chennai the respective Municipalities have given contracts to private companies for producing marketable compost from the solid wastes being generated in their area. The incentives to the private companies include allotment of land on lease, assurance of a fixed quantity of wastes every day, subsidy on the purchase of equipment and tax holidays for specified periods on the income from sale of the produce from the plant.

3.6.1 INDIAN EXPERIMENTS ON RESOURCE RECOVERY

One of the most successful composting plants in India is the Hebbal Pilot Plant of the Karnataka Agro Industries Corporation in Bangalore, which was started in 1975 as a pilot operation. The pilot project effectively demonstrated that wastes comprising of household and market refuse can be subjected to windrow composting without any prior treatment to produce fairly good quality marketable compost. In 1977 the plant was using 30 tons of wastes per day and all compost being produced was sold at Rs. 50 to 55 per ton. Data on the operating cost of the plant was not available, but the sustained operation of the plant can be presumed to imply profitability of the operation ***(Frank Flintoff, 1984)***.

In early nineties, a Bangalore based engineer, Mr. K. Shivaprasad developed a system for recovery of energy from garbage. The process involves a number of stages. The garbage is first sieved to remove large sized ingredients, sent through magnetic separators for removing the ferrous scrap and then heated in an inclined rotary kiln between 150 to 200C to dry and sterilise it. For heating the kiln, the dry garbage itself or any other fuel can be used. The dry garbage is screened to remove sand and plastics as well as metallics. It is then shredded and sent through an air classifier, where the combustible portion, being lighter, gets separated. The non- combustibles or inorganic materials are then used for landfilling. The combustible portion is then made into pellets. A binder could be used for pelletisation or the lignin in the vegetable matter in the garbage itself can also serve as a binder. The pellets are further dried in a rotary hot air drier to around 8 to 10 percent moisture level and are then ready for use. According to Mr. Shivaprasad the pellets have a heating value of 4000Kcal/kg and a bulk density of 500kg/cu m due to the high amount of biomass present in the Indian refuse. About 100 kg of moist garbage yield about 30 kg of fuel pellets. The ash residue is only 5 percent of the pellet weight and is a good potassic fertilizer. The cost of setting up a 30 tonnes pellet a day capacity plant is around Rs. 1.5 crores (at 1995 pricing).

The fuel pellets are an excellent domestic fuel, since they burn without a smoke in contrast to charcoal and firewood. Due to high heating value lesser quantity of the fuel can produce better heating in lesser time. According to its inventor, this process will not only reduce the nuisance of ill disposed garbage but also be economical in terms of saving precious fossil fuels and firewood. The pellets can also be used in small thermal power plants.

Another indigenous treatment method developed from traditional Indian treatment processes for wastes is the Vermicomposting process developed and systematised by Bhawalkar Earthworm Research Institute in Pune. This cost effective method needs no complex equipment and negligible energy inputs. This process utilises the ability of the earthworms to disintegrate the biodegradable portion of the Municipal Solid Wastes. The earthworm's gut provides ideal temperature, pH and oxygen concentration for the speedy growth of useful aerobic bacteria and actinomycetes and thus has a very high microbial density about 1000 times greater than in the surrounding soil. The worm also produces enzymes which break complex biodegradable matter present in the garbage into simpler compounds which are used by the micro-organisms. The earthworm is capable of feeding on the wastes and reducing its size to 2 microns size thus providing a greater surface area for microbial action. The blood haemoglobin in worms has a very high oxygen affinity and is thus available for the micro-organisms in high concentrations. The oxygen rich micro-environment accelerates the aerobic decomposition and eliminates the anaerobic micro-organisms.

The micro-organisms in the earthworm's gut produce useful compounds like antibiotics, vitamins, plant-growth hormones etc. which are all present in its vermicastings. They also destroy all the pathogens in the ingested waste thus rendering the vermicastings safe. These vermicastings make good bio-fertilizers. This is one of the cheapest and easiest methods of processing organic fraction of the MSW. Vermicomposting can be effectively used to process wastes even at the community level in both urban and rural areas due to the simplicity and low cost of the process. But segregation of the biodegradable organic fraction of the waste is a pre-requisite.

Although such indigenous and effective methods of processing MSW have been developed in India, it is seen that many Municipalities have chosen expensive and sophisticated processes like incineration, for which equipment and expertise has been imported and almost all such systems have failed due to the physical and chemical characteristics of the Indian wastes as discussed earlier in this section.

3.7 DISPOSAL OF SOLID WASTES IN INDIAN CITIES

Disposal of the solid wastes in Indian cities is not done scientifically and is more of an "*out of sight, out of mind*" syndrome. No processing of the wastes is done in most cities. Very few cities have the organizational and administrative set-up to subject the wastes to treatment processes like composting and that too on a very limited scale. Most of the wastes are disposed by the concerned agency at an open dump without going into the details of either site or wastes. There is no adherence to any standards or norms for disposal and the site is not scientifically managed.

The landfilling practice in most Indian cities is one of the most unscientific and unhygienic practices with serious environmental implications. The wastes are brought to the site and dumped. There are no considerations for leachate, gases and cover. The landfill sites are mostly accessible to scavengers, animals and vectors.

In Bangalore again the most common method of disposal is open dumping of the wastes in the landfill sites. Bangalore has 14 such sites where the solid wastes are dumped in open heaps without any processing or treatment. There are two composting plants which can process 200 metric tonnes of SW per day and 300 metric tonnes of SW per day, however both the plants are operating much below capacity and process only one-third of their capacity. In Hyderabad there are six dumping grounds that are used to dump 800 metric tonnes of solid wastes per day. Here too the wastes are not subjected to any processing or treatment before disposal. In Calcutta solid wastes are disposed by both landfilling and open dumping- there are more than 40 such disposal grounds in addition to small private landfilling sites. These sites receive from 500 to 10 metric tonnes of solid wastes per day, depending on their size ***(Madhusmita Moitra, 1996)***.

The situation in other Indian cities too is not drastically different from that in the cities discussed above and thus the need for urgent intervention, in terms of suitable long and short term plan proposals by planners for addressing the issue, and a pragmatic approach by policy and decision makers to facilitate sustainable solid waste management programmes, to prevent any further mishap like Surat. Our cities can sustain their environment and the vagaries of development only if an all-encompassing holistic approach to town and country planning is adopted and implemented.

3.8 LEGISLATIVE ASPECTS OF SOLID WASTE MANAGEMENT IN INDIA

Most of the Municipal Acts, in vogue, in Indian cities have some provisions for the management of solid wastes.

The Haryana Municipal Act, 1973, deals with the issue of solid waste management under 'Scavenging and House Scavenging'. Sections 152 through 168 of the Act are dedicated to the subject.

The provisions of the act make the removal of offensive matter mandatory for residents served a notice for this purpose by the municipality. The act also bans the dumping of earth and solid wastes on to the streets, into drains, sewers and irrigation channels. Such offences are punishable with a fine under ,the act. The act also abolishes the practice of scavenging and carrying of night soil by persons on their head.

The Madras city Municipal Act also makes provisions for management of solid wastes vide sections 194 through 202 under the heading of Scavenging. The provisions of the act makes the municipal commissioner responsible for:

a) providing conveniently situated temporary depots or places of depositing rubbish, filth and animal carcasses.

b) providing suitable means for removal of rubbish and animal carcasses.

c) provide covered vehicles or vessels for removal of filth.

The act also has provisions for issuance of public notice ordering removal of rubbish and filth by occupier from his premises.

Section 198 of the Madras Municipal Act provides for daily cleaning of streets and removal of rubbish and filth as a responsibility of the commissioner.

The Act also prohibits the dumping of animal carcass, rubbish or filth on streets, verandahs, open spaces, bank of water course or tanks.

The other Municipal Acts too have provisions such as above. However, due to soft punitive measures and weak implementation mechanism, there is a rampant abuse of the laws leading to a crisis like situation of solid wastes in most cities.

The Hon. Supreme Court of India ordered constitution of a committee in 1997, for suggesting improvements in SWM practices in Class 1 cities in India. As a consequence of the Committee's recommendations, the Ministry of Environment and Forests gave notification of the Draft Municipal Solid Wastes (Management and Handling) Rules, 1999, in the Gazette of India on 27 Sept 1999. The draft was passed by the legislature in October 2000 and has been named as the Municipal Solid Wastes (Management and Handling) Rules, 2000.

The Rules lay down broad guidelines for SWM including collection, segregation, storage, transportation and disposal of municipal solid waste. The rules also provide for setting up of certain mandatory infrastructure in respect of SWM. Further a system of annual reporting by municipalities to State Pollution Control Boards (SPCB), who in their turn shall submit annual reports to Central Pollution Control Board (CPCB). The CPCB shall also prepare a consolidated report to document the implementation of these rules. The guidelines recommended by the Municipal Solid Wastes (Management and Handling) Rules, 2000, are as follows:

(a) House to house collection of garbage.

(b) Biodegradable wastes to be managed to make use of such wastes.

(c) Bio-medical and industrial wastes not to be mixed with MSW but to be handled as per rules pertaining to these.

(d) Wastes should not be burnt.

(e) Measures to create awareness about recycling and reuse of segregated waste materials.

(f) Provision and maintenance of adequate storage facilities by civic authorities.

(g) Transportation of MSW in appropriate vehicles to prevent any health and environmental impacts.

(h) Daily collection of garbage from communal collection facilities.

(i) Collection and transportation to be organised to avoid multiple handling of wastes.

(j) Processing of solid wastes to be organised by the civic authorities so that the burden on landfilling can be minimised.

(k) Composting/other processing methods to be adopted for solid wastes.

(l) Landfilling shall be engineered.

(m) *Landuse plans for towns and cities to incorporate landfilling sites.*

In addition to these, the rules also lay down guidelines for civic authorities for regulating many other essential aspects of SWM including the type of storage systems to be used for communal storage, vehicles to be used for transportation of wastes, processing of biodegradable wastes, and final disposal of process residues and non-biodegradable wastes. However the rules are not comprehensive and need to be modified and developed over a period of time to encompass all functional elements of SWM. The rules also need to lay down more detailed monitoring mechanism and implementation system for each and every aspect of SWM, including strict punitive measures for failure to comply with the rules.

3.9 ROLE OF NON GOVERNMENTAL ORGANIZATIONS (NGOS) AND COMMUNITY BASED ORGANIZATIONS (CBOS) IN SWM

In a resource starved and populous country like India, the government agencies are unable to provide the quality as well as quantity of the services and infrastructure to an extent that is desirable. Under such a situation it is not only a great relief to the government but also to the population itself if Non Governmental Organisations (NGOs)and Community Building Organisations (CBOs) come forward to initiate action and execute these functions on behalf of the government at an affordable expense, under the control of the government. The greatest advantage that the NGOs and the CBOs have over the government agencies is the willing participation of the communities in their activities. The NGOs and CBOs in some cities like Bangalore, Madras, Bombay, Pune etc have been able to mobilize communities to get involved in the process of SWM. The details of some of the NGOs involved in SWM in some Indian cities are given in the Table below.

CITY	BANGALORE	DELHI	CHENNAI	BARODA
NGO INVOLVED	CENTRE FOR ENVIRONMENTAL EDUCATION	SHRISHTI	CIVIC EXNORA	BARODA CITIZEN COUNCIL
ACTIVITY	DOOR TO DOOR COLLECTION, RECYCLING	DOOR TO DOOR COLLECTION, STREET CLEANING AND COMPOSTING	DOOR TO DOOR COLLECTION, LANDSCAPING	DOOR TO DOOR COLLECTION
METHOD OF DISPOSAL	VERMI-COMPOSTING	COMPOSTING	DISPOSED AT COMMUNITY BINS	DISPOSED AT COMMUNITY BINS
SERVICE CHARGES (Rs. Per Month)	10/-	20/-	10/- TO 25/-	30/-
SALARY EARNED BY WORKERS (Rs. Per Month)	500/-	500/-	--	450/- TO 500/-
FINANCE				
TOTAL COLLECTION	27,000/-	10,000/-	--	
OTHER SOURCES	11,000/-	11,800/-	--	
EXPENDITURE	37,000/-	21,300/-	--	

CITY	BANGALORE	DELHI	CHENNAI	BARODA
SAVINGS	1000/-	500/-		
EXTERNAL LINKAGES	BANKS, MUNICIPAL CORPORATION, OTHER NGOs	MUNICIPAL CORPORATION OF DELHI, WORLD WILDLIFE FUND, OTHER NGOs	PRIVATE FIRMS, CORPORATIONS, ROTARY CLUB	CORPORATION AND WITH OTHER NGOs

TABLE 3-6: ROLE OF NGOS AND CBOS IN SOLID WASTE MANAGEMENT (Source: Venkateswaran, Sandhya, 1996)

The main thrust of almost all NGOs and CBOs has been in the process of collection and segregation waste. The NGOs and CBOs have created awareness amongst the communities on the need and practice of appropriate SWM at community levels and mobilized residents to segregate the wastes and collect wastes from households and dump it into municipal bins. Thus the immediate environment of the community involved is kept clean. This also enables the municipal service to concentrate its efforts towards secondary transportation, thus improving the efficiency of the SWM system.

Given the right impetus and appropriate incentives the NGOs and CBOs role can be enlarged to encompass transportation, processing, recycling and disposal of wastes at neighbourhood level. Thus the effective incorporation of these organizations in SWM process can go a long way to reduce the burden on the Urban Local Bodies (ULBs).

3.10 EXPENDITURE ON SOLID WASTE MANAGEMENT IN INDIA

On studying the expenditure pattern of some cities' municipal budgets, we find that a large percentage of the budget goes towards sanitation and public health and yet the solid waste management scenario remains dismal, with low collection efficiency and improper processing and disposal methods being still employed. The details of expenditure on SWM in some Indian cities are given in table 3-7 below. From the table we can infer that the expenditure pattern varies significantly from one Indian city to another due to variation in the quantities of waste generated, collected, transported and disposed. The differential cost per ton in different cities can be attributed to the lack of a uniform national policy and objectives for solid wastes management (SWM). The SWM policies and objectives are a localised phenomenon, with the Municipalities laying down the parameters for functioning of the system. This leads to differential qualitative and quantitative manifestations in SWM systems for different cities.

CITY	REVENUE EXPENDITURE IN CRORES	TOTAL BUDGET IN CRORES	COST PER TON IN Rs.
BANGALORE	23.4 (21.2%)	110.00	294.00
DELHI	61.3 (19.7%)	310.00	613.10
CALCUTTA	26.7 (17.2%)	155.44	336.12
HYDERABAD	15.2 (11.0%)	134.12	32.10

TABLE 3-7: EXPENDITURE ON SWM IN SELECTED INDIAN CITIES (Source: Moitra, Madhusmita, 1996)

If the objectives and policies with regard to the SWM were uniform over similar classes of cities, then in such an ideal situation the expenditures for SWM would be in similar ranges owing to the uniform quantification in similar classes of cities. The National Workshop on Solid Waste Management held in 1995 had made a recommendation for a National Policy on SWM.

In Indian cities the Urban Local Bodies (ULBs) are responsible for SWM and the expenditures have to be met from within their meagre resources. However with scarce revenue earnings, and ever increasing infrastructure requirements of the burgeoning urban populations, the services like solid waste management are the most affected and become unsustainable financially. In such a scenario, it is necessary to recognise that provision of such services as a free social obligation of the ULBs is not a viable proposition. If quality service is expected, and for environmental and health reasons it is essential, then a system where the beneficiaries of the service pay for the expenditure incurred on the service, needs to be formulated and adopted. World over the concept gaining ground is that the population that is generating solid wastes has to own up the responsibility for the safe and final disposal of its waste, and it is only under such a situation that the community's participation in the SWM process is effectively ensured.

3.11 PRIVATISATION OF SOLID WASTE MANAGEMENT IN INDIA

In generic terms **privatisation** is a reduction in government activity or ownership within a given service or industry. This implies that government activity is reduced when the private sector participates in service delivery and, government ownership is reduced when government enterprises are divested to unregulated private ownership or when government agencies are commercialised (reorganised into accountable and financially autonomous semi private enterprises). However private sector participation does not mean the exclusion of government activity from the field of intervention. In fact, the governments' role is enhanced because of the need to develop a balanced mix between the public enterprise, the private party and the community. The role of the government has been further enhanced by the 74^{th} constitutional amendment ***(Iyer, Sriparna Sanyal, 1996)***.

In Baroda, due to the severely deficient sanitation and cleaning operations by the Municipal Corporation during 1995-96, the Baroda Citizens Council formulated a plan for solid waste management in the city involving the Residents Welfare Associations (RWA). The programme was started in the colonies that were beyond the purview of municipal services. The steps involved in the implementation were a door-to-door campaign for interest generation, identification and appointment of volunteers in a colony to oversee the programme and appointment of sweepers. The LIG colonies contributed a monthly Rs. 3 to 5 per household while others paid upto Rs.30 per month per household. Commercial establishments had to pay higher rates. The system encompasses the door-to-door collection of wastes by sweepers who were employed by the RWA, and deposition of the wastes in the community bins from where the municipality picks up the wastes for further disposal.

In 1994 the Municipal Corporation of Kochi entered into an agreement with a private company Popular Environment Management Services (PEMS) through a contract for 5 years. As per the terms of the contract, PEMS would be responsible for the lifting, transporting and dumping of municipal wastes from the community bins. The corporation installed 350 metal bins to serve as community waste collectors and provided 6-7 waste collection vehicles to PEMS on rent. Operation and maintenance of the vehicles is the responsibility of PEMS which ensures effective maintenance and efficiency of the vehicles. All personnel were employed by PEMS and collection carried out in 12 hours shift per day. PEMS charged the corporation Rs. 100 per cubic metre of waste disposed at sites designated and monitored by the corporation. PEMS was responsible for collecting and dumping 130 tonnes out of the total 400 tonnes of solid wastes generated in Kochi in 1994. Thus there was scope for further expanding the private parties' role in the SWM process.

PEMS has been instrumental in working out a scientific wastes transport system for the city's waste collected by them. The collection points are fixed and the collection route is pre-designated. The vehicles collect the wastes from the community collection bins by hydraulic lifting and dispose the wastes at the disposal site. All secondary collection, transportation and disposal processes are carried out at night.

Similarly in Hyderabad, Rajkot, Bangalore, Mumbai, Faridabad, Delhi and Pune also some functions of SWM have been privatised but the scale of privatisation has been small and thus the benefits have not been perceptible except by the population directly serviced. Secondly, it is only the customer related operations of SWM that have been subject to privatisation in most cases i.e. only functions like door-to-door collection, and transportation of wastes have mostly been privatised. However private initiative in treatment and disposal of solid wastes have not been done at an equal scale. Overall the complete potential of privatised SWM programme has not been witnessed in India. However whatever instances of private participation have been initiated have been done at a level of Municipality as there were no state legislations, rules or controls governing the SWM operations and its quality. But as the cities expand and become populous, it would become untenable for the Municipalities to provide all services and infrastructure and thus it would be necessary to involve private bodies to participate in maintaining the cities.

It is also pertinent to note that world over the concept of the government's responsibility towards provision of services and infrastructure is weaning. In a market economy, most of the services would have to be paid for by the beneficiaries and the customer would be justified in demanding quality service from the provider. Thus one cannot ignore the incorporation of private participation in services. Although the privatisation of SWM processes is presently on small scale, it does offer the much needed efficiency and quality, demanded by the service.

Although privatisation has ushered greater efficiency in many of the services including SWM, in the case of an essential service like SWM, the public authority must retain the ability to provide the service in the event of a failure on the part of the private firm. Thus a larger number of private firms with small areas of responsibility should be involved in the SWM process. This would encourage competition as well as better service.

There are many different forms and methods of incorporating privatisation in the SWM process. The most common forms and methods are:

(a) Contracting

(b) Franchise

(c) Concession

(d) Open competition

Some of the prevalent methods of private sector participation in SWM are briefly discussed below.

3.11.1 CONTRACTING

This method provides the greatest opportunity for private firms to provide the service for the local governments. This is due to the relative lack of barriers for entry, technological simplicity and moderate investment costs. The contents of a good contract clearly define the measurable outputs of service required of the contractor and thus enable performance monitoring as well as defining the sanction that are to be imposed for non-performance.

In order to achieve low costs, contracts should ideally be of a length long enough to allow the contractor to depreciate for capital expenditure on appropriate equipment. Contracts for short duration severely inhibit the number of contractors willing to provide the service.

Among the various options available, contracting provides the greatest opportunity because of the possibilities of greater efficiencies even with small coverage. Also the contracts can clearly define the measurable outputs of the service required of the contractor and thus enable effective performance monitoring. Competition is a key factor to getting low cost solid waste service from private contractors.

3.11.2 FRANCHISE

Local governments own all the wastes generated within its territory once it has been discharged for collection and disposal this is a legal provision. This therefore gives the local authority the right to give exclusive franchise to a qualified private firm for the right and responsibility to provide service to customers within a Zone. The private firm has to pay a license fee to the government and can recover its costs by charging user fees. The local government retains the right to monitor the performance of the private firm and determine the user fee.

The local governments in the developing countries have found it possible to work with community groups, NGOs and co-operatives in this arrangement in the field of solid waste management. This is particularly true for low-income areas and in the case of recycling of materials. Governments may find it worthwhile to organise the informal sector into a co-operative and give them the job of waste management especially after the rights and responsibilities of the co-operative is clearly defined. Some countries have also given exclusive franchise to organisation to recover and recycle from the waste generated.

3.11.3 CONCESSION

There are generally two kinds of concession arrangements followed:

(a) **BOOT:** Build Own Operate Transfer, the private sector finances the facility, runs it for a period of time determined before hand and then transfers the facility to the government. The time period is long enough for the private firm to recover investments.

(b) **BOO:** Build Own Operate; the arrangement is similar to BOOT, the only difference being that the facility is not transferred at the end of the contract period.

3.11.4 OPEN COMPETITION

This is also termed as private subscription. In this arrangement, each household and commercial establishment hires a private collection firm and pays the fee charged by the firm for solid waste removal. This form of privatisation leads to substantially higher costs often more than that for public service.

In the context of solid waste management, this form of privatisation is resorted to in those cases where standards have been evolved and enforcement laws are strict. For example, open competition can occur at the stage when environmental standards are in place/ governments also turn to open competition in the case of maintenance and repair services.

3.12 SOLID WASTE MANAGEMENT: CASE STUDY DELHI

In the recent past Delhi has experienced a series of epidemic outbreaks of gastroenteritis and cholera. In 1994, many cases of plague were reported in Delhi. In 1996 dengue fever was responsible for more than 400 deaths in Delhi. It has already been mentioned in Chapter 1, that 22 diseases have been identified by the USPHS, as far back as 1967, which are attributable to improper SWM.

Table 3-4 shows that Delhi has a poor efficiency of garbage collection (62%) and thus it is not difficult to realize the grave environmental and public health implications of solid waste management in a city as densely populated as Delhi.

3.12.1 SOLID WASTE MANAGEMENT IN DELHI: ORGANIZATIONAL ASPECTS

There are three local bodies that are responsible for delivering municipal services in the city. The Municipal Corporation of Delhi (MCD) covers the maximum area of about 1,397.29 sq.kms (94.22%), including the rural areas; New Delhi Municipal Council (NDMC) covers an area of 42.74 sq km and Delhi Cantonment Board (DCB) covers an area of 42.97 sq km In terms of population too, 95.81 per cent of the city's population is under the MCD. The NDMC does not have the status of a proper local body as all its members are nominated. The DCB is entirely financed by the Defence Ministry of the Central government. The MCD is unique in the sense that it also looks after rural Delhi, thus it is the only urban government in India having rural jurisdiction. The area and population under each of the local bodies is given in the table below.

Local Body	Area(sq.kms) 1991	Population(lakh)	
		1981	1991
MCD	1397.29	58.62	90.25
NDMC	42.74	2.73	3.01
DCB	42.97	0.85	0.94
Total	1483.00	62.20	94.20

TABLE 3-8: AREA AND POPULATION OF MUNICIPAL GOVERNMENTS IN DELHI
(Source: Municipal Corporation of Delhi (General Wing),(1996) Memorandum to the Delhi Finance Commission)

The conservancy and Sanitation Engineering (CSE) Department of MCD is responsible for SWM and also sanitation in the area of responsibility of MCD. The CSE is headed by a Deputy Municipal Commissioner with two Directors under him, one for the Trans-Yamuna area and the other for the rest of the MCD area. The duty of the Directors (CSE) is to look after the activities related to SWM along with sanitation, with the assistance of the engineering staff. Table 3-9 gives the Staffing Pattern of MCD.

The Sanitary Superintendents look after the work of collection and transportation of solid waste in their respective zones and report to the concerned Joint Director. Apart from this, they are responsible for redressal of complaints related to collection of solid waste that are received by the Zonal Assistant Commissioner/Additional Deputy Commissioner.

Post	Number
Deputy Municipal Commissioner	1
Director	2
Joint Director	3
Sanitary Superintendent	23
Chief Sanitary Inspector	33
Sanitary Inspector	208
Assistant Sanitary Inspector	616
Safai Guide	603
Driver	661
Safai Karmachari (including daily wagers)	38113
Total	40263

TABLE 3-9: STAFFING PATTERN OF MCD
(Source: National Environmental Engineering Research Institute [NEERI], 1996)

Details of the staffing pattern of the CSE given above show that the CSE has a huge staff of 40,263 people with the lowest level staff, i.e. *Safai Karmacharis* (SKs), accounting for as high as 94.66 per cent of the total- 2000 SKs are involved in loading the waste into the trucks while the majority are essentially street sweepers. In spite of this large number an estimated 1000 sweepers are added to the labour force every year. In addition to the sweepers, the department employs 661 drivers, 616 Assistant Sanitary Inspectors (ASI), 603 *Safai Guides* and 208 Sanitary Inspectors ***(Satpal Singh, 1999)***.

The SKs, in each zone, work under the overall supervision of the Safai Superintendents (SS). At the local level it is the ASI who delineates the work beats for the SKs. The sweeping beats are delineated in each zone and a group of workers (usually 5) are assigned the job of sweeping the beat and carrying the garbage to the nearest bin. Each sweeping group is provided with brooms and two wheeled handcarts at the rate of one handcart for every two SK. Although in the MCD area there are 3.31 SKs per 1000 population the working of the CSE department is plagued with many problems. The beats are delineated not on the basis of any scientific evaluation of the routes of collection or transportation but ion the whims and fancies of the ASI. Also there is no formal system of reporting for duty by the SKs to any office, nor any designated place for keeping their equipment. The problem is further aggravated due to the high percentage of absentees that is often as high as 40 percent. In addition the lack of any formal monitoring and reporting system for the work of the SKs results in low productivity ***(ISS Manuscript Report 14, 1999)***.

3.12.2 GENERATION OF SOLID WASTES IN MCD AREA

Quantity of waste generation in any city varies due to the variation in activities, levels of income, and socio-economic status of the populace. The difference in the rate of generation within the city is primarily dependent on the income levels and activities of the population. The high generation rates in Delhi as given in table 3-10 reflect the higher proportions of industrial and commercial activities in Delhi.

	1996	1998
Population	1,14,83,213	1,22,81,4
Garbage generated @450 gms/capita/day (in tonnes)	5167.44	5526.
Garbage collected by the MCD (in tonnes per day)	3550.49	5000.
Backlog(generation-collection) (in tonnes per day)	1616.95	526.

TABLE 3-10: GARBAGE GENERATION IN DELHI AND ITS COLLECTION BY MCD, 1996 AND 1998
(Source: ISS Manuscript Report-14, 1999)

3.12.3 COLLECTION OF SOLID WASTES IN MCD AREA

As per the Delhi Municipal Corporation Act, 1957, it is the duty of the residents to deposit solid waste from their houses into municipal receptacles. In the MCD area, solid waste collected from road sweeping is also deposited in municipal receptacles by the MCD staff. Silt from the drains and waste from the roads, parks, open spaces, outside hotels and hospitals, public lavatories and urinals etc. is collected using wheel barrows and dumped in the community bins.The municipal receptacles (i.e. dalaos and dust bins of various designs and sizes and open collection points) are located at different places in the city. Where the quantity of waste, collected is large, i.e. more than two trucks load, 'dalaos' are constructed. The capacity of a dalao without a roof varies from 50 to 72 cubic meters. There are 412 dalaos operational in the MCD area ***(Satpal Singh, 1999)***.

It has been observed that the collection bins or dalaos are not cleared regularly. Also, their number is inadequate as a result of which large quantities of waste is left uncollected or just dumped in the open spaces, parks, roadside drains, etc. many of the dalaos are not of the appropriate size considering the waste that is dumped into them. To deal with this problem the Corporation has taken steps to barricade 176 dalaos. According to norms specified by the MCD, the distance from dustbin to dustbin should not be more than 100 metres. But in effect, because of non-availability of land, the distance from the residential areas to the collection centres varies from area to area as per the convenience of the people and the authorities ***(ibid)***.

Mechanical loaders are used at dalaos where large quantity of waste accumulates and the area requires frequent cleaning. Where loaders are not used, two to three workers are employed per vehicle for manually loading the waste onto the truck. About 60 per cent of the waste is collected mechanically and the rest manually.

The core staff, working at the waste collection stage, is the Safai Karamcharis (SKs), whose duties include sweeping public places, loading the waste onto the truck/lorries. They use brooms, wheelbarrows, handcarts, *belchas* etc. for sweeping and depositing solid waste in receptacles/dalaos/dustbins. The working hours for the SKs are 6.30 a.m. to 2.30 p.m. in summer and 7.30 a.m. to 3.00 p.m. in winter with a half an hour lunch break. They are given a weekly off every Sunday. Every Assistant Sanitary Inspector has a specified place in his area where the SKs working under him report at the commencement of the shift. Depending upon the density of the population, each SK is assigned an area of 3,000 to 12,500 sq m. Waste is brought to the dalao from a distance of up to 3-4 km after collection from the generation area (NEERI 1996). The productivity of the collection staff is only 93 kg of waste/worker/day during summer and 125 kg of waste/worker/day during monsoon ***(Satpal Singh, 1999).***

3.12.4 TRANSPORTATION

Waste collected from the various collection points is transported by means of mini-trucks and mechanical trucks of different makers, i.e. Tata tipper trucks, Leyland and Shaktiman trucks, having 8.6 cu m capacity and front end loaders and taken directly to the nearest disposal/landfill site. These vehicles are operated and maintained by the MCD workshop. In 1996-97, the MCD had 666 mechanical tipper trucks with a capacity of 4 metric tonnes. Of this, 470 trucks were in a working condition, while 130 trucks were under repair. Besides, the Corporation also hires private trucks with a capacity of 4 metric tonnes, for which it has been paying Rs.1,300/- for three trips. The Corporation also has 138 mechanical loaders of which only 60 loaders were in a working condition. The vehicles operate two shifts and usually make 1-2 trips per shift depending upon the distance of the disposal site. On an average, over 1100 trips are made during a day ***(ibid).***

Under-utilization of the fleet of vehicles is a major problem that results in delay in transporting the garbage from the collection points to the disposal site. The major reasons for under-utilization of the vehicles are:

(a) Improper maintenance as a result of which a number of vehicles are not functional (only 50-60 per cent of the vehicle fleet is on the roads at one time).

(b) Haphazard parking of vehicles.

(c) Time lost waiting in the queues for fuelling and while traveling from one workshop to another for fuelling in case there is no such facility in the concerned zonal workshop.

As a result, the vehicles are found to operate only two to three hours a day, and make only one or two trips from the collection zone to the disposal site. The situation is further worsened on account of the fact that during any given shift, more than 50 percent of the time is spent non-productively by the staff ***(NEERI, 1996)***.

3.12.5 PROCESSING AND TREATMENT OF SOLID WASTE IN DELHI

The solid wastes in MCD area not subjected to any organized treatment processes. No information about any compaction, sorting or screening equipment is available in any of the reports of the MCD, or other documents recording the SWM practices in Delhi. Which leads to the presumption that no such facilities are available for the treatment of the solid wastes. The details available for the SWM practices in MCD area give information of only landfilling operations and sites. There are a few composting plants in Delhi but only a very small percentage of the total solid waste is composted. In 1999, MCD had only one semi-mechanised compost plant processing 150 metric tonnes of solid wastes per day at Okhla. However the MCD had assigned the work of installation of a compost plant for processing 500 metric tonnes of solid waste per day at the Bhalswa landfill site to a private company in 1999.

There is no official data on the recycling of the material or the energy derivation from the refuse collected and disposed by the MCD. However, the informal sector is very active in promoting the reuse, recovery and recycling of the usable material in the solid wastes of the city. A large percentage of the plastic waste (almost 60%) is recycled along with a considerable share of paper and metals ***(Vishvanathan, Shiv, 2000)***. Unfortunately, a lot of hospital waste, which is considered hazardous is also recovered for direct reusc in the absence of any appropriate legislation to prevent the same.

3.12.6 DISPOSAL OF SOLID WASTES IN DELHI

In Delhi about 99% of the solid waste collected is disposed on land through sanitary landfilling (SLF) or local dumping, the remaining 1% is used for composting by the NDMC plant. The MCD manages all the sanitary landfill (except one managed by the Cantonment Board). Other agencies like NDMC, APMC. Trade Fair authority, and other private agencies dispose off their waste on MCD SLF sites by paying Tipping fee charges which varies from Rs.128/refuse collector truck (8ton), and Rs.68/tipper truck Rs.35/tempo. Area of SLF varies between 1.1 ha and 52.2 ha. The average depth of SLF is 5.0 m, and average life of landfill sites used is 4 to 6 years, though 10 out of 19 sites were found to have a life span of three or less than three years. According to prescribed sanitary landfilling norms, about 20-25% by weight of cover material should be applied on each layer of waste but present availability of landfill cover (construction debris and earth) in most landfills in Delhi is only 10% or less, thereby causing environmental problem ***(Moitra, Madhusmita, 1996)***.

Out of the 19 landfilling sites, 16 have already been filled up and are presently being converted into gardens/forests. The three landfilling sites presently in use are Gazipur, Okhla and Bhalswa in the MCD area. The MCD authorities have also identified new sites for landfilling as well as composting. These new landfilling sites are located in the peripheral areas of Delhi and their areas range from 12 to 150 acres. However, the new sites entail greater transportation expenditure due to increased travel distances and time for vehicles. Also no details are available about the suitability of the sites for landfilling in terms of geological and infrastructural requirements like access roads, electricity, water, earthcover etc.

3.12.7 SWM IN MCD AREA: A FINANCIAL OVERVIEW

There is no systematic and logical method of allocation of funds for SWM in Delhi, and that is established by pattern of expenditure incurred by the MCD on SWM in the last 20 years. The Municipal Corporation of Delhi (MCD), in their budget have shown the total expenditure on Public Health and Sanitation ranging from 20.25% in 1980-81 to 25.02% in 1996-97 to 16.85% in 1997-98, as shown in Table 3-11 below.

From the details of MCD's expenditure on Public Health and Sanitation it clearly emerges that the per capita expenditure has increased almost six times in 16 years however the quality of services remains below any measurable standard. Also, while the resident and floating population of Delhi has increased rapidly we find a reversal in the expenditure on SWM, in terms of the percentage of total expenditure of the MCD. It highlights the fact that even in the national capital there is a lack of awareness in such matters of grave environmental and health implications as solid waste management.

EXPENDITURE HEADS	1980-81	1985-86	1990-91	1995-96	1996-97	1997-98
Total Municipal Expenditure(in Rs. Lakhs)	7197.25	14671.23	30565.11	58204.75	66739.93	107887.14
Total Expenditure on Public Health and Sanitation (in Rs. Lakhs)	1389.03 (20.05) *	2944.87 (20.07) *	7932.86 (25.95) *	14428.22 (24.71)*	16699.49 (25.02)*	18182.50 (16.85)*
Per Capita Expenditure on Public Health and Sanitation (in Rs.)	24.80	41.83	88.31	132.62	143.69	151.10

TABLE 3-11: REVENUE EXPENDITURE OF MCD ON PUBLIC HEALTH AND SANITATION
(Source: Budget of MCD, 1998-99)
* Percentage of total municipal expenditure.

3.12.8 INFERENCES DRAWN FROM THE STUDY OF SWM PRACTICES IN INDIA AND CASE STUDY AREA DELHI

From the study of the composition and characteristics of wastes in various Indian cities as tabulated in chapter 3 the following facts that are of significance to the SWM process in Indian cities emerge:

a) Waste densities in Indian cities are high.

b) The moisture content of the wastes in Indian cities is also high.

c) The wastes in Indian cities have a large percentage of organic contents with high portion of vegetable/putrescible materials

d) There is a substantial amount of dust and dirt in cities where sweeping and open ground storage of wastes is part of the collection system.

e) The particle size of wastes in Indian cities is small.

Due to the above mentioned characteristics of the wastes in Indian cities the following issues relative to various aspects of application of technology become evident:

a) The sophisticated compaction equipments in collection vehicles, so commonly used in the developed countries would achieve a low compaction for the dense Indian wastes.

b) Landfill dozers/compactors would achieve insignificant compaction ratio as compared to high compaction ratio of 6:1 in developed countries.

c) Due to the high moisture content of the wastes in Indian cities, incineration would generally not be self sustaining and would require energy input rather than produce recovery energy.

d) For the Indian city waste with high organic content, biodegradation techniques such as methane generation and composting are technically more viable.

e) Since the particle size of wastes in Indian cities is small, size reduction facilities such as shredders would not have any significant implications for further processes.

f) Materials which can be recovered for reuse using expensive and sophisticated processes such as air floatation and magnetic separation are present in such small amounts that these processes are not economically viable.

The following inferences are drawn from the case study of SWM in MCD Area in Delhi:

(a) Due to the strained financial health of the MCD, and the severe pressure of a massive and rapidly increasing population on the already deficient infrastructure, the institutional arrangement for the management of SW in MCD area of Delhi is not fully effective leading to the drawbacks in the system.

(b) There are no regulations governing the generation, segregation and onsite storage systems, thus hindering optimum functional efficiency of the management of solid wastes.

(c) The collection system is not scientifically organized and the community collection system too is inadequate and improperly planned, thus preventing the optimum use of human and equipment resources of the MCD.

(d) The wastes are transported, irrespective of their nature and hazard, by means that necessitate multiple handling at various points. This is not only dangerous for the persons handling the wastes but also reduces the overall efficiency of the collection system.

(e) There are no formal and/or institutional provisions for the recovery, reuse and recycling of the wastes, due to which there is no economic returns to any institution of the formal sector from the process of SWM. This leads to disinterest on the part of agencies involved in SWM. As a consequence the involvement of the

CHAPTER 4

GENERAL INTRODUCTION TO HARDWAR

4.1 GENERAL

Hardwar is one of the main religious centers of India. The city of Hardwar is the district headquarters of Hardwar district. In addition to its status as an important pilgrimage destination for Hindus, it is also an important center for trade, commerce, industry and service in the region.

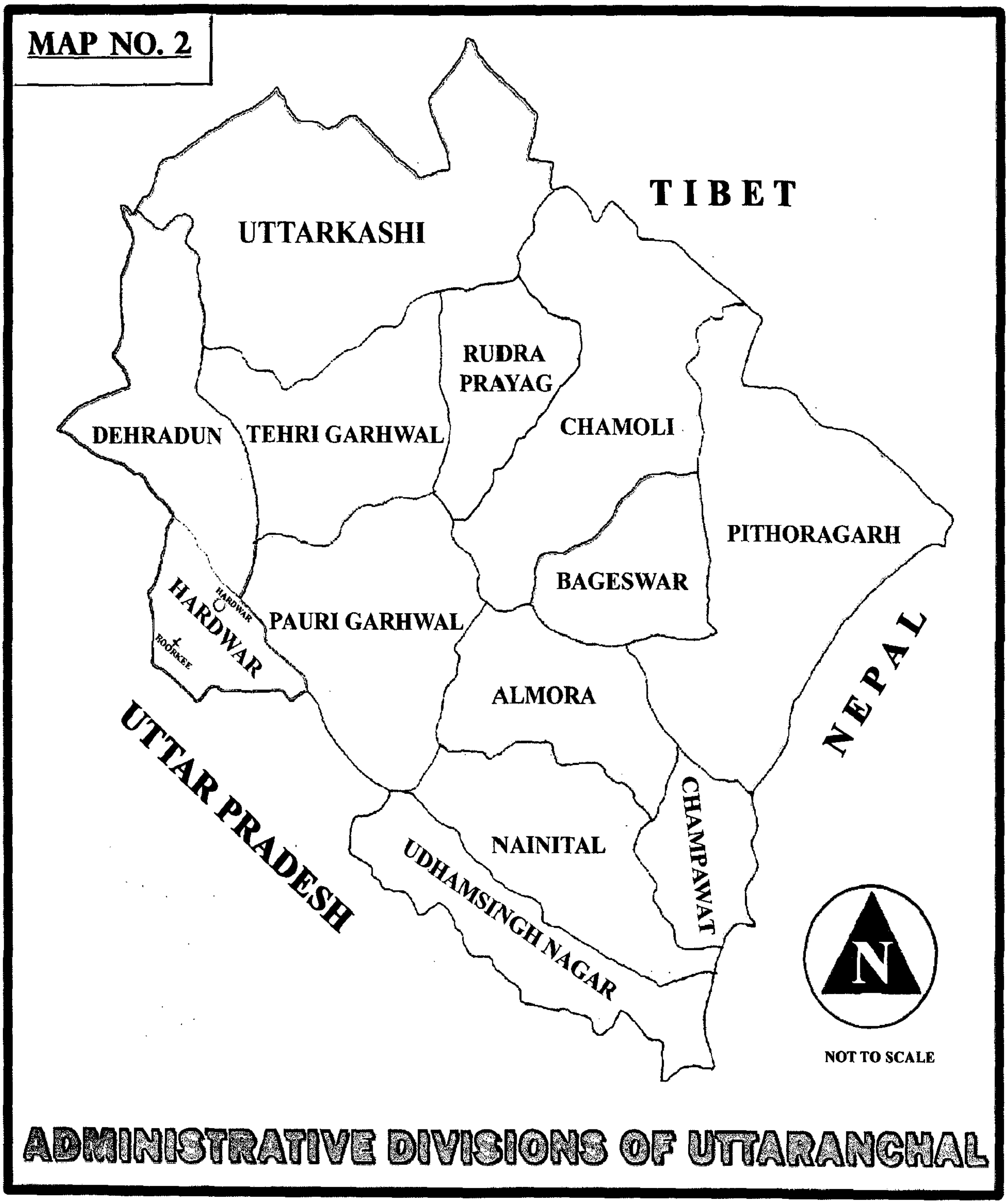
Before the creation of Uttaranchal state in November 2000, the district of Hardwar was part of Uttar Pradesh (Refer Map 1). With the creation of Uttaranchal state, the district of Hardwar, along with the city have become part of the newly formed hill state. (Refer Map 2). The city of Hardwar today forms the gateway to the hill state of Uttaranchal. The inclusion of Hardwar, in the new state, has increased the economic importance of the city manifold, as it is proposed to develop the city as a major communications and commercial centre for the new state.

The district of Hardwar was earlier created in 1988, from the district of Saharanpur. The formation of the district with its headquarters at Hardwar city gave an impetus to the trade, commerce and service industry in the city. The rapid economic growth of the city led to increase in population and consequent urbanization and physical development of the city albeit unplanned and uncontrolled.

One of the major factors affecting the socio-economic development of Hardwar is the large number of pilgrim/tourists who visit the city throughout the year. The occurrence of Kumbh Mela, once every twelve

MAP NO. 1

LOCATION OF UP AND UTTARANCHAL



ADMINISTRATIVE DIVISIONS OF UTTARANCHAL

years and the Ardh Kumbh Mela, once every six years, are two occasions when the city assumes the demographic dimensions of a megapolis.

As a consequence of the rapid increase in population and uncontrolled urbanization, the physical infrastructure development of the city has not been able to keep pace. In addition the large pilgrim/tourist inflow to Hardwar has also imposed a tremendous load on its already deficient infrastructure. Moreover the Nagar Palika Parishad (NPP), Hardwar, the Urban Local Body for local governance in Hardwar is plagued with finance crunch, which has severely inhibited the development of infrastructure in Hardwar. The present system of local governance makes the Nagar Palika Parishad (NPP), Hardwar, responsible for maintenance and operation of essential services like water supply, sewage disposal, drainage system and solid wastes management. In this scenario of deficiencies, the solid wastes management in Hardwar is one of the most adversely affected amongst the essential services.

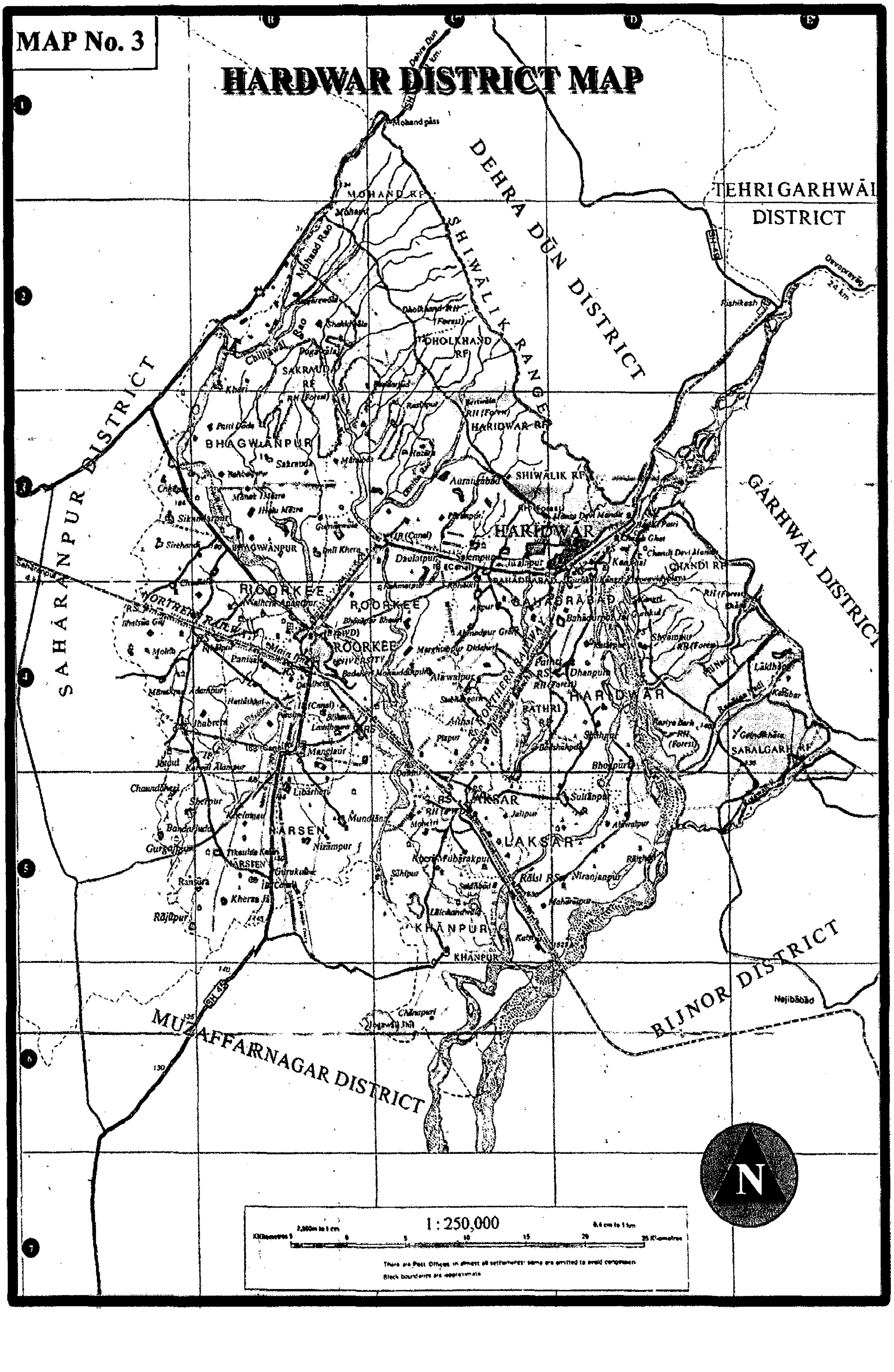
4.2 PHYSICAL CHARACTERISITICS OF HARDWAR CITY

The city of Hardwar is laid out linearly along the Roorkee - Rishikesh axis i.e. the National Highway Number 58 (NH 58). The city having an area of 12.78 km (less BHEL) is bounded by the River Ganges on its east and by the jungles and mountains of Shivalik ranges on its west. While the development of the city towards its east is negated by the presence of the River Ganges, there has been limited development in the hilly western part (Refer Map 3).

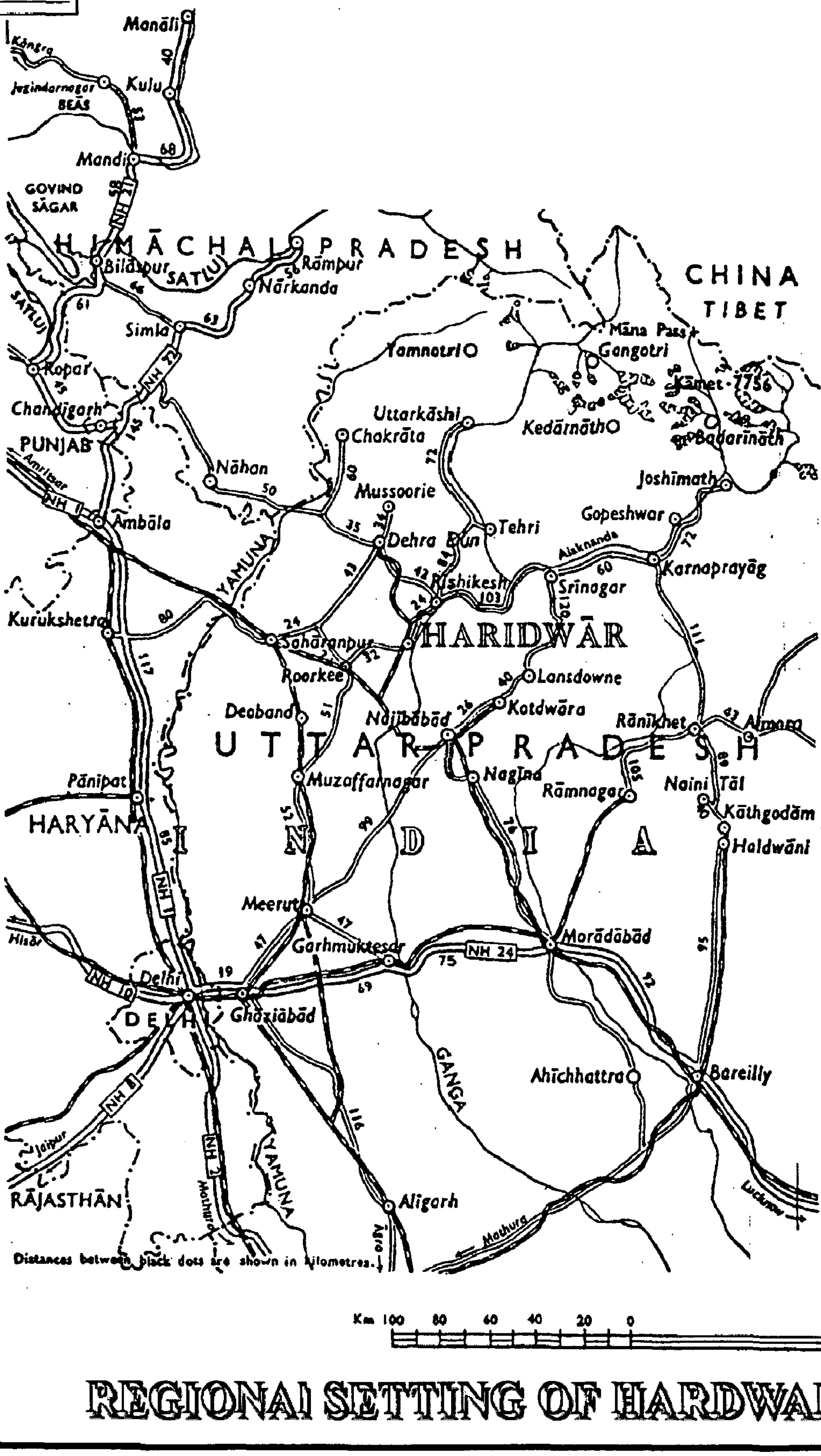
Hardwar district is surrounded by the districts of Dehradun, Garhwal, Bijnor, Muzaffarnagar and Saharanpur.

MAP No. 3

HARDWAR DISTRICT MAP

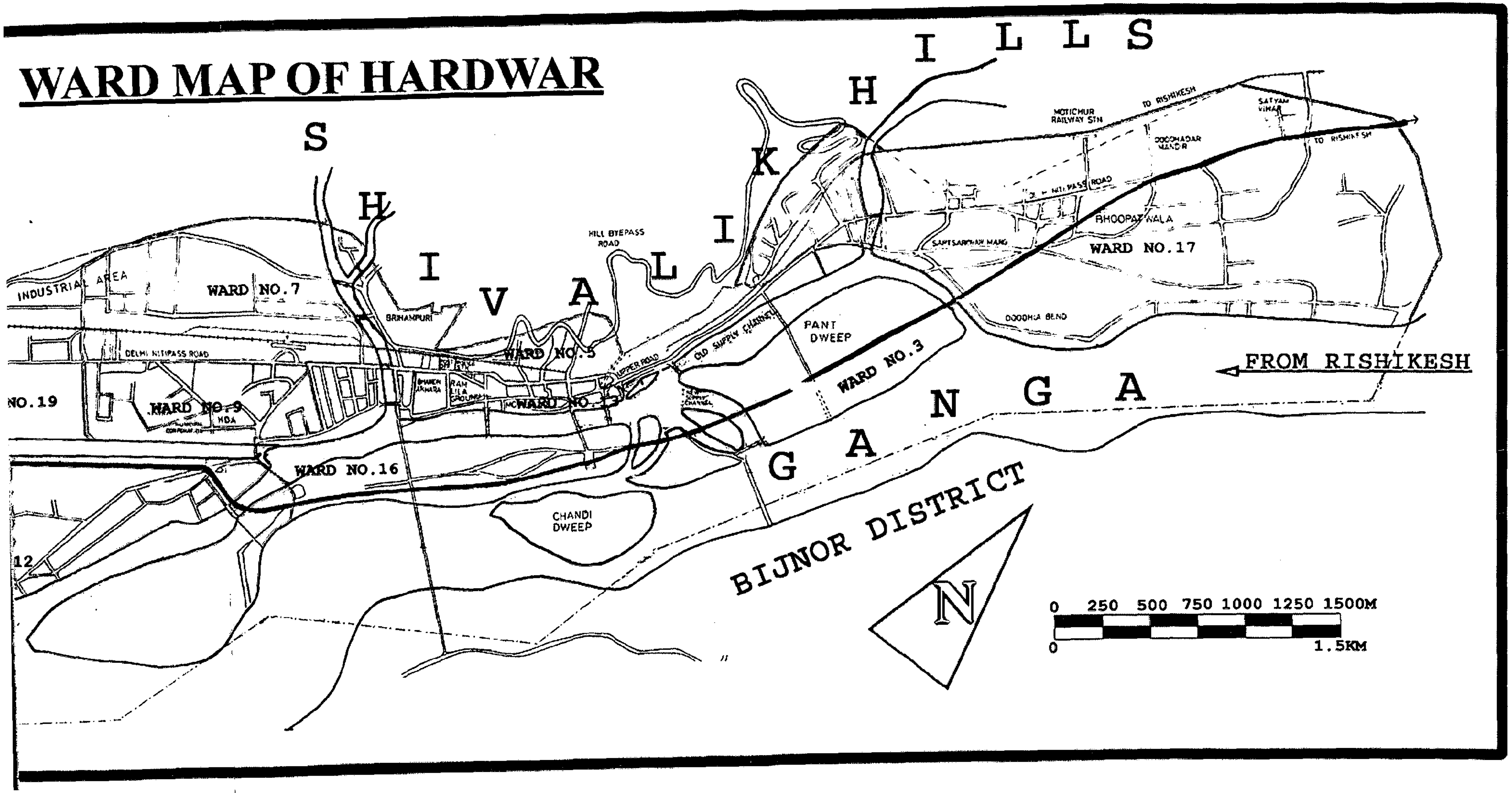


MAP NO. 4



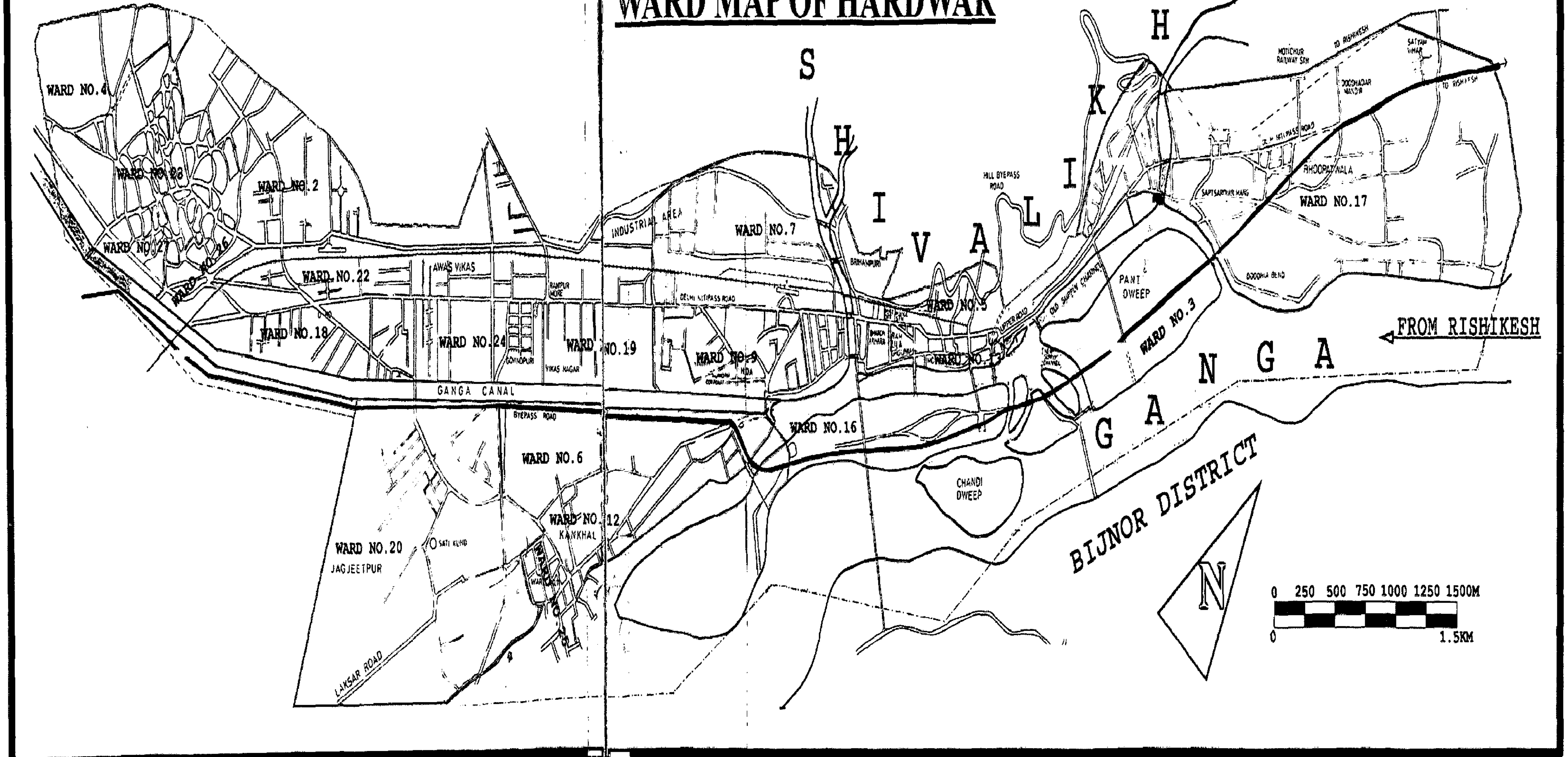
REGIONAL SETTING OF HARDWAR

WARD MAP OF HARDWAR



MAP NO. 5

WARD MAP OF HARDWAR



4.2.1 GEOGRAPHICAL LOCATION OF HARDWAR

Hardwar is located at Latitude 29°58′ North and Longitude 78°10′ East in the foothills of Shivalik Mountain ranges and the plains commence from here.

The city lies along the NH 59, between Roorkee and Rishikesh and is well connected by rail and road. The city is linked to other major cities like Dehradun (52 km), Meerut (141 km), Saharanpur (81 km) and Lucknow (494 km) by both road and rail. (Refer Map 4).

4.2.2 NATURAL RESOURCES, SOIL, VEGETATION AND HYDROLOGY

The dense forests and thickly vegetated mountains in its proximity makes Hardwar an important center for timber trade as well as for medicinal plants, shrubs and herbs/ the forests and mountains around it are rich in biodiversity and the greenery offers a salubrious environment to the city.

The area is characterized by Shivalik system and alluvium rocks and the predominant soils are Tarai and alluvial soils which are highly fertile and productive. Wheat, rice barley, gram, bajra, arhar and sugarcane are the most common crops in the region.

The average depth of ground water table is 25.35 feet and the ground water potential is high with yields upto 10 litres/second. The high ground water table renders it easily prone to contamination from solid wastes due to the inappropriate storage and disposal practices for solid wastes.

4.2.3 TOPOGRAPHY

The area is flat with gentle undulations and has a large number of small nalas criss-crossing the land to form the drainage network, in addition to the river Ganges flowing north to south along the city.

The lie of the ground is gently sloping from northwest to southeast and the city of Hardwar is at an elevation of approximately 350 meters from mean sea level.

4.2.4 CLIMATE

Hardwar experiences a climate of extremes with temperatures soaring to a maximum of 42°C in summers and dipping to 1.3°C in winters. The peak summer months are May and June while the severe cold climate is prevalent in December and January. Hardwar also receives a high annual rainfall with an average of 46.67 inches.

The tropical climate of Hardwar mandates a proper system of solid wastes storage, collection and disposal to prevent a foul and malodourous environment due to high content of putrescible matter. Also land and water (both surface and ground) are more liable to pollutants from solid wastes due to the climatic conditions prevalent in the area.

4.3 LANDUSE PATTERN

The city of Hardwar is divided into three main parts, namely Hardwar city, Kankhal and Jwalapur which are further sub-divided into 27 Wards (Refer Map 5). The rapid and unplanned growth of the city has resulted into haphazard development. Mixed landuse is predominant in most parts of the city. Combined with haphazard development, the mixed landuse poses a complex problem for any planning process intended to improve the situation. Commercial, industrial, official landuse are commonly found mixed with residential landuse in Hardwar.

The mixed landuse pattern poses the typical problem of receiving diverse waste streams from a single area, ideally necessitating different methods of handling, storing, processing, transportation and disposal. In the present mixed landuse scenario of the city, it would be indeed very difficult to effectively manage such diverse waste streams from an area or locality without proper survey and study of the waste streams and compositions.

The landuses for the city of Hardwar for the year 1985, are given in table 4-1 below:

LANDUSE	AREA (IN ACRES)	PERCENTAGE OF TOTAL AREA
BUILT UP AREA		
RESIDENTIAL	627.89	21.4
COMMERCIAL	30.58	1.0
INDUSTRIAL	148.55	5.1
COMMUNITY FACILITY	148.76	5.1
TRANSPORTATION	105.78	3.6
GOVT. & SEMI GOVT. OFFICES	33.68	1.1
RELIGIOUS PLACES	242.98	8.3
CAMPING	277.48	9.5
TOURIST PLACES	4.95	0.2
UNDEVELOPED AREA		
OPEN SPACE	468.18	16.0
PARKS AND GARDENS	252.69	8.6
AGRICULTURE	315.74	10.8
JUNGLE	42.35	1.4
WATER BODIES	232.23	7.9
TOTAL	2931.84	100.0

TABLE 4-1: LANDUSE DISTRIBUTION OF HARDWAR IN 1985
(Source: Master Plan of Hardwar, 1985-2001)

As mentioned earlier the landuse pattern of a city has grave implications for the solid waste management in the city. The quantity, composition and characteristics of the wastes depends on the type of landuse from which the waste has generated. In case of pure landuses the waste composition is similar from all sources but for mixed landuse pattern the waste composition is more varied. This differential quality of the wastes, from different types of sources, when stored in the same communal storage, collected together and treated together significantly reduces the efficiency of the treatment process, which can not be effective for a wide range of waste composition and characteristics.

4.4 DEMOGRAPHIC PROFILE OF HARDWAR

Hardwar is one of the most populous districts amongst the thirteen districts of Uttaranchal. The population details of Hardwar are given in the table 4-1.

Year	Population	Decadal Growth	Decadal Growth Rate
1901	26,597	-	-
1911	28,682	3,085	12.05
1921	30,764	2,082	7.26
1931	33,287	2,523	8.20
1941	40,823	7,536	22.64
1951	57,338	16,515	40.46
1961	59,960	2,622	4.57
1971	79,277	19,317	32.22
1981	1,15,513	36,236	45.71
1991	1,74,000	58,487	50.63
2001 (projected)	2,35,074	61,074	35.1
2021 (projected)	4,29,063 (by exponential method)	-	-

TABLE 4-2: POPULATION GROWTH OF HARDWAR
(Source: Master Plan of Hardwar, 1985-2000, Census of India, 1991, and Hardwar Nagariya Awasthapna Suvidhaoan Ka Blueprint, 2000-2003)

The Ward wise voters' number is the most reliable information on the ward wise distribution of population, in the absence of any reliable information on the ward wise population. For the purposes of this thesis report the ward wise distribution of voters (in terms of percentage of total number of voters) has been assumed as the basis for the distribution of the population in Hardwar city. Table 4-2 gives the ward wise number of voters, their percentage to total number of voters and the projected population of the wards based on percentage of voters in each ward i.e. the population of each ward has been assumed to be the same percentage of the total population as the percentage of voters in that ward. This projection of the ward populations based on the percentage of voters in each ward gives us a fair idea of the present population distribution in Hardwar. The ward wise population figures that are officially available pertain to 1991 and are thus, not of much significance for working out the details of any facility/utility. However the ward wise voters list for the city of Hardwar is available, which was estimated by the NPP, Hardwar in the year 2000 and is presumed to be fairly accurate due to its significance for the elections of the NPP, Hardwar.

WARD NO.	WARD NAME	NUMBER OF VOTERS	PERCENTAGE OF VOTERS	WARD POPULATION (projected)
1	KADACH	3,432	3.05	7,170
2	AMBEDHKAR NAGAR	3,759	3.34	7,851
3	TIBRI	5,319	4.72	11,095
4	VALMIKI BASTI	4,194	3.72	8,745
5	JOGIYA MANDI	4,142	3.68	8,651
6	RAVIDAS BASTI	4,625	4.11	9,662
7	NIRMALA CHAWNI	2,814	2.50	5,877
8	KHADKHADI	4,962	4.40	10,343
9	MAYAPUR	3,318	2.94	6,911
10	MAIDANIYAN	5,081	4.51	10,602
11	KOTARWAN	2,914	2.59	6,088
12	ACHARYAN	3,405	3.02	7,099
13	HAR KI PAIRI	4,958	4.40	10,343
14	GAUGHAT	2,592	2.30	5,407
15	MEHTAN	1,954	1.73	4,067

WARD NO.	WARD NAME	NUMBER OF VOTERS	PERCENTAGE OF VOTERS	WARD POPULATION (projected)
16	SHRAVANNATH NAGAR	3,009	2.67	6,276
17	BHOOPATWALA	6,945	6.16	14,481
18	ARYA NAGAR	5,989	5.32	12,506
19	RISHIKUL	3,947	3.50	8,228
20	KRISHNA NAGAR	5,335	4.74	1,1143
21	CHAKLAN	4,848	4.30	10,108
22	AWAS VIKAS	4,658	4.14	9,731
23	LAKADHARAN	3,257	2.89	6,794
24	GOVINDPURI	4,449	3.95	9,285
25	RAJGHAT	3,663	3.25	7,640
26	LODHAMANDI	5,219	4.63	10,884
27	KASSAWAN	3,878	3.44	8,087
TOTAL		1,12,666	100.00	2,35,074

TABLE 4-3: WARD POPULATION PROJECTED ON THE BASIS OF DISTRIBUTION OF WARD WISE VOTERS
(Source: Voters List, 2000, Nagar Palika Parishad, Hardwar)

The average household size in Hardwar is 5 as per the various reports of the Nagar Palika Parishad (NPP), Hardwar. With the projected population figure of 2,35,074 for the year 2001, it is estimated that there are about 47,015 households in Hardwar presently.

The overall literacy rate of Hardwar city was 60.01% in 1981 with male literacy rate of 64.2% and female literacy rate of 35.8%. As per the various reports and records of Nagar Palika Parishad, Hardwar, the overall literacy rate increased to 75.01% in 1991 and the estimated overall literacy rate in 1999 stands at 90.09%. The high literacy rate is a positive indicator and would be a catalyst for the implementation of awareness and community participatory programmes that may be planned in Hardwar for any development projects.

In the context of solid wastes management, the generation of solid wastes is a first order function of the population. In the management system too, the population/community has major role to play by its participation and/or intervention. Thus the population is the single most influencing variable in the entire process of Solid Wastes Management (SWM).

The rapidly increasing population and the increasing socio-economic importance of Hardwar has made the city a hub of commercial activities, in addition to the religious importance of the city. In such a scenario it is pertinent to plan for the development of the city in a manner that is most amenable for upholding the sanctity and social relevance of the city. The environmental quality of the city has to remain of very high standards to be able to sustain the development and also continue to attract tourist and pilgrims alike. The aura of holiness is most tangible in unpolluted and safe environment.

4.5 FLOATING POPULATION AND ITS IMPACT

It is estimated that on an average Hardwar has a floating population of 1 lakh visiting it every day. This large non-resident population, equalling nearly half of Hardwar's permanent population, exerts a tremendous load on the existing deficient infrastructure of the city.

In addition to the average floating population of 1 lakh, on a number of other religious occasions there is an inflow of very large number of pilgrims. This amounts to tremendous shock loads for the city's infrastructure, inspite of the very humble requirements of the pilgrims in general. For an effective SWM plan in Hardwar, it is essential to cater for the storage, collection, processing and disposal of the excess solid waste generated by the pilgrims/tourists on such occasions, in addition to its regular quota of SW. Some such occasions when large member of pilgrims/tourists visit Hardwar and their approximate numbers on each day of the occasions is given in Table 4-3 below.

Occasion	Population/day In Lakhs	Duration in days
Nav Ratri	07	9
Guru Nanak Jayanti	12	1
Makar Sankranti	08	1
Mauni Amavasya	13	1
Samvati Amavasya	15	1
Vasant Panchami	05	1
Magadh Purnima	06	1
Maha Shivratri	04	1
Kavad Mela	20	30
Shravan Mela	20	30
Nav Sambatsar	05	1
Ram Navami	03	1
Baisakhi	15	1
Lunar Eclipse	05	1
Ganga Dashera	07	1
Solar Eclipse	10	1
Guru Purnima	05	1
Char Dham Pilgrims	05	60

TABLE 4-4: FLOATING/TOURIST POPULATION IN HARDWAR ON VARIOUS OCCASIONS
(Source: Various Reports of Nagar Palika Parishad, Hardwar)

4.5.1 MOVEMENT PATTERNS OF FLOATING POPULATION

While planning for any city's infrastructure, it is essential to plan for the floating population too, in addition to the permanent population, present and projected. This becomes more pertinent in the case of Hardwar, where a major quantum of commercial activities is related to tourist and pilgrim population.

To provide the city a satisfactory level of infrastructure, in the present day's context it would be mandatory to optimise the provision based on the need and usage. The requirements of the permanent population are directly related to their activities and are easier to cater for due to the unchanging placement. Although, it is not so easily done as said, the needs of a permanent population can be more systematically catered to over a period of time. However, in the case of floating population the issue poses a greater challenge. To pre-empt the requirements of the tourists/pilgrims (with varied interests and purposes), and catering for the same, requires serious consideration and meticulous planning.

In the case of Hardwar, to provide the basic physical infrastructural framework for the floating population, it is necessary to study the major movement patterns of the pilgrims and tourists.

Whatever be the religion, case, creed, sex and nationality of the tourists in Hardwar, the primary objectives of a majority are to see the various places of religious significance and to bathe in the holy Ganges.

The various places of religious significance and tourists interest in Hardwar are shown on the Map (Refer Map 6). It is evident from the location of these sites on the map that most temples, holy sites and Ashrams are located to the west of upper Ganga canal river Ganges and are situated in the area between Hardwar railway station and Shanti Kunj, a linear distance of approximately 7 kms. In addition to these some other temples and Ashrams are also situated in Kankhal and on the eastern bank of Ganges, on crossing over through the New Lalita Rao Bridge.

All these places have large numbers of pilgrims during festival days and during the summer tourist season. The intensity of tourist movement in various parts of Hardwar is shown in the map (Refer Map 7). The waste generating activities at these sites include floral and other offerings to deities and food/snacks consumed by the visitors including large quantities of packaged eatables like biscuits, namkeen and wafers. Although the temple/ashram/holy site premises are meticulously kept clean, the surroundings are a dismal scene of littered plastics and metal foils, mainly from packaging materials of fast foods and packaged food.

Most of the boarding and lodging arrangements for tourists in Hardwar is restricted to the Upper Road and the Lower Road. Both these roads also have the main commercial areas of Hardwar from the tourists' point of view. The area between the Upper road and Upper Ganga Canal has high-density residential and commercial (mixed) landuse, with a large number of hotels, dharamshalas, restaurants, sweets shop, vegetable market, souvenir shops, general stores, textiles shops and booksellers. Obviously due to the interesting nature of the commercial area, both the permanent and floating populations frequent it, leading to extreme crowding and congestion, more so on festival days and tourist seasons. The local permanent population tends to stay away from these areas during such times.

Due to the presence of a large number of tourists pilgrims in these areas during the festival days and tourist season there is a large quantity of solid wastes being generated which includes the food and vegetative wastes from the restaurants, hotels, Dharamshalas, increased packaging wastes like plastic bags, cardboard paper, soft drink bottles and cans. However, the actual dimension of the problem can be visualized if we consider an average festival day when out of a five lakh people even if 20% (i.e. 1 lakh) visits this area and play a part in solid waste generation activities like eating in restaurant, purchasing packaged snacks and soft drinks etc.

Inevitably it is observed that this area between the Upper Road and the Upper Ganga Canal has a problem of wastes littered around in open heaps by roadside and lanes and drains and sewers choked with solid wastes. Due to the paucity of bins/dalaos in the area, the shopkeepers, including the restaurants and sweet shops, throw the food wastes into the drains and sewers.

In view of the acute problem of solid wastes in these busy and crowded city core areas, it is pertinent to plan for the solid wastes management keeping in mind the requirements of the floating population.

Another problem faced by the city of Hardwar is the excessive movement of traffic during the "Yatra" season, when there is a large pilgrim population moving to Kedarnath and Badrinath shrines via Hardwar and Rishikesh.

4.6 EXISTING INFRASTRUCTURE OF HARDWAR

Since the planning process for development of any city has as an essential agenda, the development of the infrastructural framework of the city, the knowledge of existing infrastructure would provide a helpful insight into deficiencies and requirements.

The infrastructure deficiencies of Hardwar are manifest in the commonly observed problems with roads, sewerage and drainage system, water supply, slums and squatter settlements etc. to name a few.

The inadequacies of the infrastructural framework have led to physical degradation, environmental pollution and loss of aesthetic appeal of the city.

4.6.1 ROADS

Hardwar is an important road junction of a number of regional roads from Delhi, Dehradun, Rishikesh, Najibabad and Laksar. There are a large number of vehicles passing through the city and as a result, there is mixing of intra-city and inter-city traffic. Although the NH 58 is supposed to bye-pass the city, on festival days and during peak tourist season the effects of the mixing of traffic is acutely felt.

The existing roads in the city has developed as a consequence of the haphazard development and the physical constraints to spreading of the city due to the hills and the river on either side of Hardwar. The roads in the core area (Har Ki Pairi area) are narrow lanes with built up form on both sides. It is unsuitable for any vehicular traffic but as it houses the main commercial area of Hardwar, bullock/house carts, rickshaws, handcarts and two wheelers ply on the road causing congestion and inconvenience to pedestrians.

The lengths of the different types of roads in Hardwar are:

(a) Blacktopped/Cemented all weather (Pucca) road-105.224 km.

(b) Unpaved Road-31.647 km.

(c) Unpaved fair weather road-8.420 km

(Source: Hardwar Development Authority (H.D.A.), Hardwar)

In addition to the gross inadequacy of the roads in the city the situation is further worsened by permanent and temporary encroachments on the roads and shoulders, on street parking and lack of proper maintenance.

4.6.2 SLUMS AND SQUATTER SETTLEMENTS

With the increase in trade, commerce and tourism in Hardwar, it is acting as a magnet for the region's potential migrant population. Also due to the high floating population, the city is prone for squatting.

As per a survey by Nagar Palika Parishad, Hardwar (NPP), in 1997, there were 19 slum areas in Hardwar city with a population of 66,370 in 10,500 households. This is approximately 30% of the city's population ***(Hatwal, M. K., 2000)***.

The slums lack basic facilities like piped water supply to houses, toilets, drainage and solid wastes removal. In addition many of the slums are located in low-lying areas which get frequently inundated during monsoons.

The location of increasing number of squatter settlements on the environmentally sensitive banks of river Ganges poses a potential threat to the already fragile environmental state of the river. The areas reserved as camping grounds for Kumbh Mela is also being encroached upon and as a consequence there is an overall environmental and aesthetic degradation of the city.

4.6.3 SEWERAGE

The 90 km of sewer lines in the city collects 30 MLD (Million Litres per Day) and transports it to the only treatment plant at Jagjeetpur, with the help of 11 sewage pumping stations. The sewage treatment plant at Jagjeetpur has a capacity of treating 18 MLD only and thus 12 MLD is discharged untreated into the Ganges. (As per officials of Ganga Pollution Control Unit (GPCU) of U.P. Jal Nigam)

The above mentioned 30 MLD does not reflect the actual quantity of sewage generated since many of the unauthorized and illegal residential units as well as the 19 slum areas housing a population of more than 66,000 is not served by the sewerage system.

In Jwalapur, though there is a sewer network collecting sewage, due to the absence of any sewage treatment plant, the sewage is disposed off into nearby agricultural fields.

Another major problem to the sewerage system in Hardwar is posed by the siltation in sewers due to the excessive flow of silt loaded storm water from the hills during monsoons. As a result the sewer pipes get choked and sewage overflows on the surface through manholes.

The major problems of sewerage system as identified in a study ***(Hatwal, M. K., 2000)*** are summarized below:

a) Sewerage system is inadequate.

b) Collection and conveyance system is to be laid in 20% of the area.

c) Sewage treatment plant capacity is to be augmented.

c) Siltation of sewer pipes.

4.6.4 DRAINAGE SYSTEM

The hill ranges on the northwest of Hardwar are characterized by hill streams with frequently shifting channels. During the rainy season, the area witnesses heavy precipitation in the catchment area as a result of which these streams flow with swift currents and there is frequent occurrence of flash floods. These streams and the flash floods carry a lot of vegetative debris and silt from the loose soil of hill slopes.

In addition to the problem of siltation of sewer pipes, there is a widespread problem of silt accumulation in drains and road surface as well as the Ganga Canal. The siltation of the Ganga Canal had reached such levels that it necessitated a massive desilting operation of the canal recently.

4.7 LOCAL SELF GOVERNMENT IN HARDWAR

The Urban Local Body (ULB) for local self governance in Hardwar is the Nagar Palika Parishad (NPP), Hardwar. The Nagar Palika Parishad (NPP), Hardwar has its jurisdiction within the municipal area. The area of responsibility of Nagar Palika Parishad (NPP) is divided into 25 wards.

The wards are geographical entities with district boundaries. Each ward has a Ward Commissioner who is elected by the ward population and represents the Ward in the Nagar Palika Parishad (NPP).

The (NPP), Hardwar, is headed by a chairman, elected directly by the voters of Hardwar. The NPP, Hardwar is thus a democratic institution of urban self-governance. The functioning of NPP, Hardwar, is governed by the U.P. Municipalities Act, 1916 as amended from time to time and adapted for the city of Hardwar vide the Hardwar Municipal Board Act, 1956.

The obligatory functions of the (NPP), Hardwar as per the Uttar Pradesh Municipalities Act are given below:

1. The construction, maintenance and cleansing of drains and drainage works.
2. The construction maintenance and cleansing of public latrines, urinals etc.
3. The scavenging, removal and disposal of filth, rubbish and other obnoxious material.
4. The regulation of places of the disposal of the dead and the provision and maintenance of places for the said purpose.
5. The registration of births and deaths.
6. The establishments and maintenance of dispensaries and maternity and child welfare centers and carrying out of measures necessary for public medical relief.
7. The construction, maintenance, alterations and improvements of public streets, bridges, culverts, causeway and the like.
8. The lighting, watering and cleaning of public streets and other public places.
9. The establishment and maintenance of schools for primary education.
10. The maintenance of municipal offices.
11. The construction and maintenance of public parks, gardens or recreation grounds.
12. Arrangements for public vaccination and inoculation.
13. The establishment and maintenance of government hospitals.
14. The construction and maintenance of market areas.

15. The removal of obstructions and projections, in or upon streets, bridges and other public places.

16. The maintenance of heritage sites like ghats etc.

The elected Ward Commissioners are responsible for their wards' upkeep and maintenance in respect of the obligatory functions. Being elected representatives, they are accountable to the population in their respective wards.

4.8 THE FINANCIAL ARRANGEMENTS FOR NAGAR PALIKA PARISHAD, HARDWAR

The fiscal base of most ULBs in India is weak and inadequate to meet the expenditure of rendering services to the populace and performing its obligatory functions. But the bane is not the financial crunch as much as poor planning and inefficient management of services.

The Nagar Palika Parishad (NPP), Hardwar, is also suffering from lack of finances, however, poor planning measures have further worsened the services provided by the NPP to the city.

From the income and expenditure statements of the NPP, Hardwar, it is evident that the fiscal base of the NPP is poor and is reflected from the quality and standard of the services provided by the NPP in the municipal areas. In addition to the poor fiscal base the collection systems for various taxes, tolls and charges, levied by the NPP, are inefficient. Also there is rampant corruption in the assessment and collection staff for various types of taxes, tolls and charges. No proper database is available for the services provided by the NPP and such a work culture is suitable for the ensuing malpractices.

Some of the major sources of earning for the NPP, Hardwar are listed below along with the average earning from 1996 to 1999, actual earning for the 1999-2000, and projected earning for the year 2000-2001:

Name of Source	Average Earning per year 1996-1999(Rs.)	Actual Earning 1999-2000(Rs.)	Projected Earning 2000-2001(Rs.)
House Tax	35,72,330	42,74,239	70,00,000
Rents from Land/shops etc.	25,223,118	22,24,605	35,00,000
Water Tax	46,02,094	55,12,575	85,00,000
Land/Crops Sale	45,24,739	1,61,30,310	2,00,00,000
Water charges	5,66,214	7,27,956	10,00,000
From general industries	5,46,186	48,18,011	60,00,000
License Fee from Lodging	2,65,201	3,82,862	5,00,000
Houses	97,661	1,59,276	6,00,000
Unplanned Income	5,13,799	70,843	2,00,000
From Government	4,20,68,504	3,83,51,565	5,35,00,000
Stamp Fees	18,09,303	-	80,00,000
Miscellaneous Income	33,98,259	56,02,700	50,00,000
Government Grant	2,76,72,000	-	20,00,000
Non Government Loans from	(In 1997-98)		
Bank	10,04,443	-	10,00,000
Permanent Advance	4,48,853	58,659	5,00,000

TABLE 4-5: SOME MAJOR SOURCE OF EARNING OF NPP, HARDWAR (Source: Budget of NPP, Hardwar, 2000-2001)

Some of the major expenditure heads of the NPP, Hardwar, the average expenditure per year from 1996-1998, actual expenditure for 1999 - 2000 and the projected expenditure for 2000 - 2001 on these major heads are given in the Table 4-4. The expenditure under each head includes the pay and allowances of all staff as well as expenditure for execution of works/operation and maintenance of services.

Ser. No.	Expenditure Head	Average Expenditure per year from 1996-1999 (Rs.)	Actual Expenditure 1999-2000(Rs.)	Projected Expenditure 2000-2001 (Rs.)
1	General Administration	24,77,263	34,68,464	50,00,000
2	Tax Collection	35,21,278	52,40,131	77,00,000
3	Lighting Arrangements	42,21,144	20,30,941	23,00,000
4	Water Supply Establishments	77,86,937	1,23,53,994	1,40,00,000
5	Sewer Lines Cleaning	7,45,545	6,93,839	12,00,000

6	Drainage Arrangements	-	10,84,643	20,00,000
7 8	Solid Waste Management	1,99,17,501	2,97,79,578	3,35,00,000
9	Public Health & Sanitation	50,47,665	45,44,824	60,00,000
10	Public Health & Sanitation Establishment	12,88,651	19,96,629	20,00,000
11	Hospital &	2,41,882	2,87,947	5,00,000
12	Dispensaries	6,17,631	72,574	20,00,000
13	Construction of Buildings	1,45,83,615	28,66,350	30,00,000
14	Road Construction	1,96,159	2,17,947	3,00,000
15	Schools & Colleges	1,84,621	42,772	20,00,000
16	Interests on loans	6,22,662	10,06,147	15,00,000
17	Public conveniences	2,11,098	2,68,076	4,00,000
18	Printing & Stationery	18,786,036	35,09,498	70,00,000
19	Pensions	25,498,537	33,51,532	50,00,000
20	Tourist Tax	37,52,546	24,09,302	1,00,00,000 30,00,000
21	Miscellaneous Expenditure	11,28,9565	-	
22	Non Govt. Loans Repayments	3,71,466	8,63,601	10,00,000
23	Return of Permanent Advances	15,800	1,000	5,00,000

TABLE 4-6: SOME MAJOR EXPENDITURE HEADS OF NPP, HARDWAR
(Source: Budget of NPP, Hardwar, 2000-2001)

A summary of the incomes and expenditures of the NPP, Hardwar for the last five years i.e. from 1996 to 2001 is given in the Table 4-5

YEAR →	1996-97	1997-98	1998-99	1999-2000	2000-01 Projected
TOTAL INCOME (Rs.)	4,89,487,032	10,23,75,285	7,58,05,594	7,91,08,680	11,96,86,100
PREVIOUS BALANCE (Rs.)	48,32,154	30,64,587	96,42,081	64,64,541	50,06,794
TOTAL (Rs.)	5,37,79,186	10,54,39,872	8,54,47,675	8,55,73,221	12,46,92,894
TOTAL EXPENDITURE (Rs.)	5,07,14,599	9,57,97,791	7,89,83,134	8,05,66,427	11,96,85,000
BALANCE	30,64,587	96,42,081	64,64,541	50,06,794	50,07,894

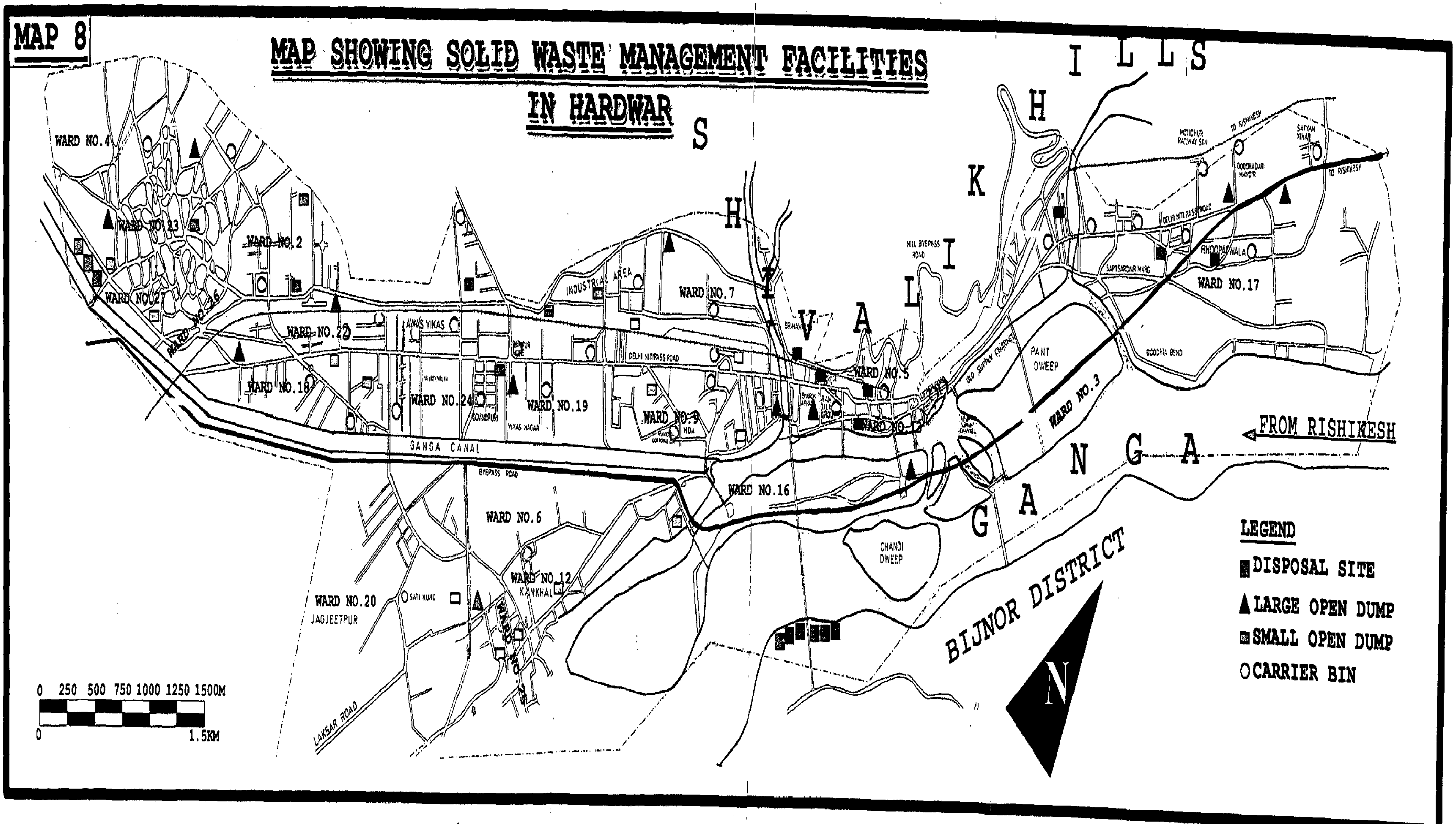
below:

TABLE 4-7: TOTAL INCOME AND EXPENDITURE STATEMENT OF NPP, HARDWAR
(Source: Budget of NPP, Hardwar, 2000-2001)

coupled with the flourishing tourism industry in the city, it can be further improved to make the financial health of the NPP.

MAP 8

MAP SHOWING SOLID WASTE MANAGEMENT FACILITIES IN HARDWAR



CHAPTER 5

EXISTING SOLID WASTE MANAGEMENT PRACTICES IN HARDWAR

5.1 THE ORGANISATION OF MUNICIPAL AGENCY FOR SWM IN HARDWAR

In Hardwar the Solid Waste Management is an obligatory function of the Nagar Palika Parishad (NPP), Hardwar. The function is performed by the Solid Waste Management and Surface Sanitation division, of the Public Health and Sanitation (P.H.&S) Department.

As per the Chief Food and Sanitary Inspector, Nagar Palika Parishad, Hardwar, the role and responsibilities of the Solid Waste Management and Surface Sanitation division of Public Health and Sanitation Department of the NPP, Hardwar is:

1. Street sweeping.
2. Desilting and cleaning of sewers.
3. Desilting and clearing of drains and nalas.
4. Removal of solid wastes from surface and storing in community collection bins/dalaos.
5. Collection and transportation of wastes from bins to disposal sites.
6. Spraying and spreading of hygiene chemicals in the city.

5.1.1 MANAGEMENT AND MAINTENANCE STAFF OF NPP, HARDWAR ENGAGED IN SWM

The different services that are provided within the purview of Solid Waste Management in Hardwar are directly under the Public Health and Sanitation Department of NPP, Hardwar. There is a hierarchical structure of the organisation, which looks after the functioning of various aspects of SWM. The SWM staffs are divided into Management staff and the Maintenance staff. The various personnel under the Management and Maintenance staff are given in Table 5-1 below.

Management Staff	
Health officers	- 02
Chief Sanitary and Food Inspector	- 01
Sanitary and Food Inspector	- 04
Sanitary and Food Asst Inspector	- 16
Drivers (permanent)	- 13
Drivers (on contract)	- 07
Safai Karmachari (SK)	- 400
Maintenance staff	
Head fitter	- 01
Machine operators	- 03
Compressor operators	- 02
Mechanics	- 06
Service pump operators and helpers	- 06

TABLE 5-1: DETAILS OF STAFF INVOLOVED IN SWM IN HARDWAR
(Source: Chief Food and Sanitary Inspector, NPP, Hardwar)

It can be seen from the table that the staff engaged in SWM is grossly inadequate since the Indian SWM systems have labour intensive methods of collection, transportation and street cleaning operations that require a large number of workers. The World Health Organisation prescribes a minimum of 2 to 3 SKs per 1000 population ***(ISS Manuscript Report, 1999)***. It would be pertinent to mention here that the average number of SKs in the entire MCD area in Delhi is 3.31 per 1000 of population, in addition to a large number of vehicles and automated equipment for SWM in Delhi ***(ibid)***. The number of SKs in Hardwar is much lesser than even the lower figure of 2 SKs per thousand for the permanent population alone. If we take into consideration the floating population and their contribution to the city's solid wastes then the number of SKs is grossly deficient. In the case of a city like Hardwar, where the mechanisation of SWM processes is almost non-existent and the system relies primarily on the labour force, it would be desirous to have a minimum of 2.5 to 3 SKs per 1000 population. In case the number of SKs is brought up to some comparable figure, the other administrative and technical staffs also has to be augmented for better monitoring and control of the SWM processes. Another glaring anomaly in the staff for SWM in Hardwar is the absence of any technical personnel in the department. It is not only indicative of the poor planning and management capability in the government bodies and ULBs, but also a sheer lack of awareness and concern, that there is no appointment of a technically qualified person for the technical management of solid wastes. Ill-qualified and unconcerned staff deals with an important aspect of urban management like SWM.

5.2 THE FINANCIAL ARRANGEMENTS FOR SWM IN HARDWAR

The expenditure for solid waste management in Hardwar includes the expenditure under the following heads:

a) Pay and allowances of all staff involved in SWM.

b) Operation and maintenance of all vehicles and equipment related to solid waste management.

c) Cleaning of Sewer lines and de-silting operations.

d) Procurement of new equipment.

e) Upkeep and maintenance of workshop.

The expenditure for Solid Waste Management in Hardwar viz a viz the total expenditure by NPP, Hardwar is given in Table 5-2.

	1996-97	1997-98	1998-1999	1999-2000	Projected for 2000-2001
Expenditure on SWM(Rs.)	1,72,38,122	1,99,16,974	2,25,98,308	2,97,79,578	3,35,00,000
Total Expenditure by NPP (Rs.)	5,07,14,599	9,57,97,791	7,89,83,134	8,05,66,427	11,96,85,000
% Expenditure for SWM	33.99%	20,79%	28,61%	36.96%	27.99%

TABLE 5-2: EXPENDITURE ON SWM IN HARDWAR
(Source: Budget of NPP, Hardwar, 2000-2001)

From the above statements of income and expenditure it is clearly established that the expenditure on SWM in Hardwar ranges from 20-35% approximately of NPP's total expenditure. Approximately 50% of the expenditure on SWM goes towards pay and allowances of the staff involved in SWM. The balance amount is used for actual SWM operations of communal storage, collection and transport of the solid wastes to the disposal site. The expenditure of NPP, Hardwar, compares favourably with the expenditures incurred on SWM by the ULBs in other Indian cities, in terms of percentage of total expenditure of the ULBs (Refer Table 3-7), however the service remains as unsatisfactory as it is in most other cities.

5.3 GENERATION OF SOLID WASTES IN HARDWAR

Hardwar is a city with a small and manageable population of approximately two and a half lakhs, albeit growing rapidly. In the absence of any major industries within the municipal area of the city, the municipal solid wastes comprise mainly residential, commercial, institutional and hazardous wastes from households in addition to the construction and demolition debris. However, as per the Report of the Committee Constituted by the Hon. Supreme Court of India, the average per capita generation rate for cities with population in the range of 1 to 5 lakhs is low (Refer Table 3-2). The field survey by the author in Hardwar has ascertained (as discussed in Section 5.5.6) that the existing SWM infrastructure in Hardwar is grossly inadequate to deal with even the present quantities of solid wastes that are being actually generated in Hardwar. In the event of increase in population or generation rates or both, the city would face a severe crisis of managing its solid wastes.

As per the Chief Food and Sanitary Inspector (C.F.S.I.), Hardwar, the permanent population served every day by the SWM setup in Hardwar is 2,25,000 and in addition solid wastes added to the city's waste by a floating population of approximately 1,00,000 per day are also catered for. The generation rates of the permanent population, the floating population and the total solid wastes generated in the city as projected by the C.F.S.I., Hardwar, is given in section 5.3.1 below. However, as discussed earlier and in section 5.5.6 these projections are not realistic and are not based on any systematic study or survey, but appear to be exaggerated for reasons of higher budgetary allocations.

5.3.1 DETAILS OF SOLID WASTE GENERATION IN HARDWAR: AN OFFICIAL VERSION

It has already been mentioned in Section 3.2, that there is no system of measuring the solid wastes generated in Indian cities. In the absence of any measured data, the per capita solid waste generation rates and the total quantity of solid waste being generated in Hardwar too, is subject to speculation and exaggeration to the benefit of the SWM authorities. As per the C.F.S.I., Hardwar the per capita generation rates are as given below:

(a) Permanent residents- 600 grams per capita per day.

(b) Floating population- 300 grams per capita per day.

Based on the generation rates details and population figures given by the C.F.S.I., Hardwar, the total quantities of solid wastes that are generated in Hardwar calculated below.

<u>Total solid wastes generated by the population in Hardwar</u>

By permanent population =2,25,000x600/1000 = 135000 kg.
= 135 metric tonnes

By floating population =1,00,000 x 300 / 1000 = 30,000kg.
= 30 metric tonnes

Total solid wastes generated by the population
(Permanent and Floating) in Hardwar = 165 metric tonnes

<u>Silt accumulation in Hardwar</u>

Summer monsoon silt = 6814 metric tonnes approx.
(in June-July-August)

Average silt per day (summer monsoons)=70 metric tonnes

Winter monsoon silt =2555 metric tonnes approx.

(in December-January-February)

Average silt per day (winter monsoon) =28 metric tonnes

Rest of the year silt =1000 metric tonnes approx.

Average silt per day (rest of year) = 6 metric tonnes per day

When we add the seasonal silt to the solid waste generated the total quantity of wastes to be handled increases significantly.

The total average daily solid waste generated in Hardwar during non monsoon period = 171 metric tonnes

The total average daily solid waste generated in Hardwar during winter monsoon period = 193 metric tonnes

The total average daily solid waste generated in Hardwar during summer monsoon period = 235 metric tonnes

(Source: C.F.S.I., P.H.&S. Deptt. Nagar Palika Parishad, Hardwar)

Thus, we find that the SWM authorities in Hardwar project a very high solid waste generation rate in Hardwar. If we take into consideration the projected seasonal fluctuation in silt generation the total solid waste generation increases by almost 16% (during winter monsoon) to 41% (during summer monsoon). By the simplest of logic, an increase in generation implies a proportionate increase in all infrastructures for SWM, as well as the manpower requirements for various functions of SWM.

5.4 ONSITE HANDLING, STORAGE AND PROCESSING PRACTICES IN HARDWAR

After the solid wastes are generated, the manner in which it is handled, stored and processed play a very major role in deciding the subsequent functional elements as explained in chapter 2 earlier. In the case of most Indian cities there is very little significance attributed to this crucial functional element by way of regulatory measures and legislative directions by the Urban Local Bodies, or otherwise, as discussed in Chapter 3. Hardwar too faces the same dilemma.

The waste storage methods, for different types of municipal solid wastes, vary in Hardwar. However, the lack of any handling and processing added to the fact that the storage is mostly in form of open heaps of waste on ground on the access roads and lanes makes not only the first process of handling, processing and storage deficient but grossly undermine all further management efforts, which also are highly disorganized and unscientific. It would be pertinent to note here that a large quantity of food wastes from households, restaurants, dhabas etc. are fed to animals by the generator, a practice which is in built in the traditional fabric of Indians and an ingenious way of disposing food wastes, but the practice poses a health threat to the animals nevertheless. Another very important fact that the physical survey and discussions with residents of Hardwar brought to light was that no formal onsite processing of the wastes was done in Hardwar, except some open burning which is the least desirable of all practices.

In the light of the foregoing, the only function performed at the generation point is storage of the wastes from the different sources. The various methods of storage practices in Hardwar are described in the following sections.

5.4.1 STORAGE OF RESIDENTIAL SOLID WASTES IN HARDWAR

Most households in Hardwar dispose off their wastes on a daily basis so generally whatever storage methods are used, the maximum storage capacity of any storage device is for one day's waste only. Physical survey and discussions with many people established that two-bin storage of wet biodegradable and dry non-biodegradable solid wastes is unheard of. All wastes are stored and disposed off together. Also, households with small children stored and disposed diapers and faecal matter along with the solid wastes.

A wide range of containers was found to be in use, for storage of wastes by households in Hardwar. Some of the most common ones are listed below:

a) Plastic/metallic containers of 5 to 10 litres capacity
b) Used plastic bags
c) Cardboard cartons
d) Newspapers
e) Cane baskets

The use of storage devices at homes is a typical practice of HIG and MIG households. The LIG households and areas of LIG residents generally do not store the wastes and tend to dispose their wastes directly in Community Bins (Dalaos/Carrier bins/Open Dumps). However, in some HIG and MIG residential areas in Hardwar, it was observed that households were just throwing the wastes on the access roads. This practice can be attributed to absence of any storage devices at home and non-availability of community storage devices nearby. In some area, households were found to be using the SK's open handcarts directly for storing the wastes and it is indeed a convenient option for locations where placing of other communal storage devices is difficult due to lack of space.

5.4.2 STORAGE OF COMMERCIAL AND INSTITUTIONAL SOLID WASTES IN HARDWAR

A small percentage of commercial and institutional establishments have any formal onsite waste storage devices. Those establishments, which do have some storage facilities, are able to store their wastes for maximum one day.

The most common storage devices are:

a) Plastic/metallic containers of 25 to 100 liters capacity

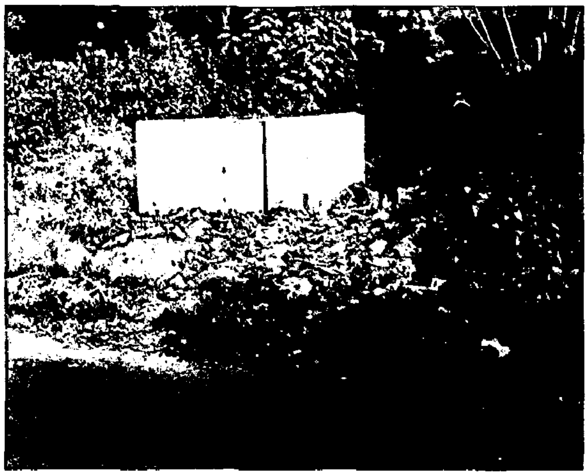
b) Used plastic bags of various sizes

a) Cane/Wicker baskets

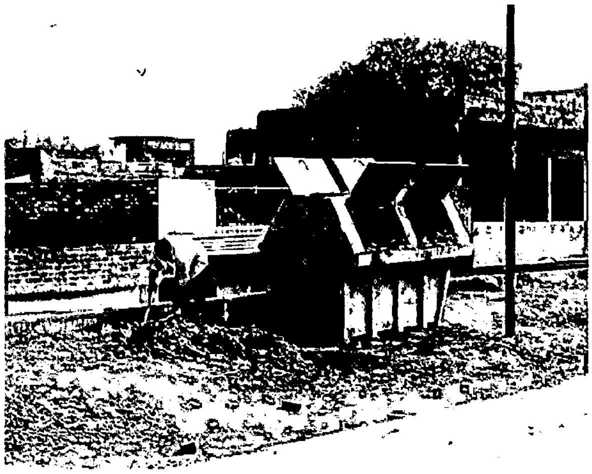
Most restaurants, hotels, dharamshalas and ashrams use some or the other storage devices for kitchen wastes, however, only the bigger hotels have storage facilities for other dry solid wastes. The dharamshalas and ashrams are prone to dumping other dry wastes outside their premises, while the food wastes are stored in buckets and either fed to the animals and/or dumped into community storage arrangements (dalaos/bins/open dumps). Since these institutions generate large quantities of wastes during the peak tourists' season it is necessary that these institutions make proper arrangements for storing their solid wastes in the most appropriate manner.

5.4.3 STORAGE OF CONSTRUCTION AND DEMOLITION WASTES IN HARDWAR

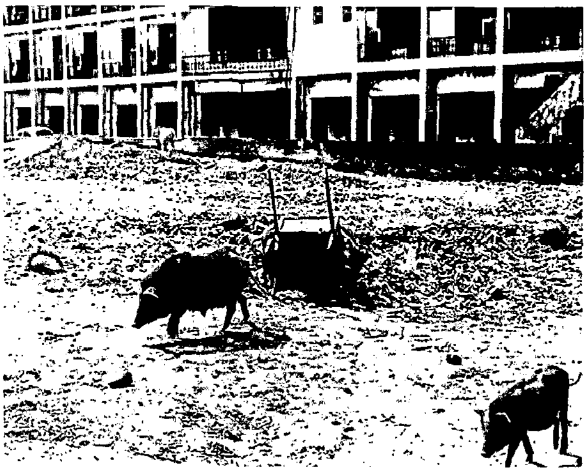
In the absence of any regulations controlling storage of construction and demolition debris in Hardwar, it is commonly observed that construction and demolition debris is dumped outside the premises of the generator (See Plate 1 E). Many a times the roadsides are a common storage space for these debris, significantly reducing available road space and creating bottlenecks for traffic. However, the most common practice is to dump the debris (if it is of no resale value) onto a nearby open space/vacant plot and even in open dumps of solid wastes. The municipality authorities remove this debris only when it becomes a nuisance to either the traffic or the people.



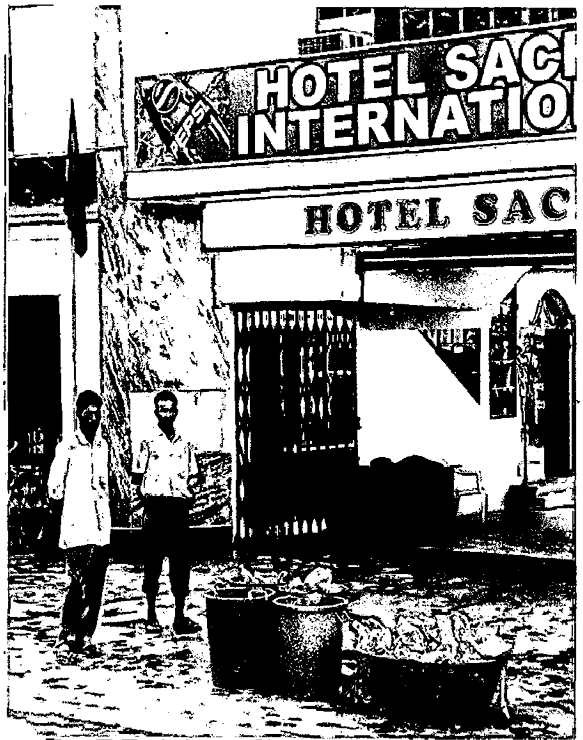
A. DALAO



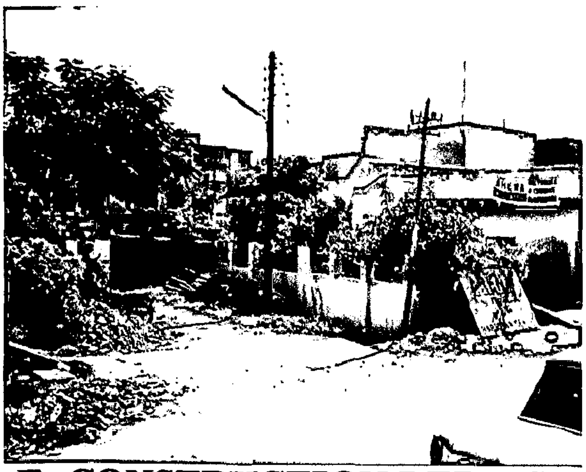
B. CARRIER BIN



C. OPEN DUMP



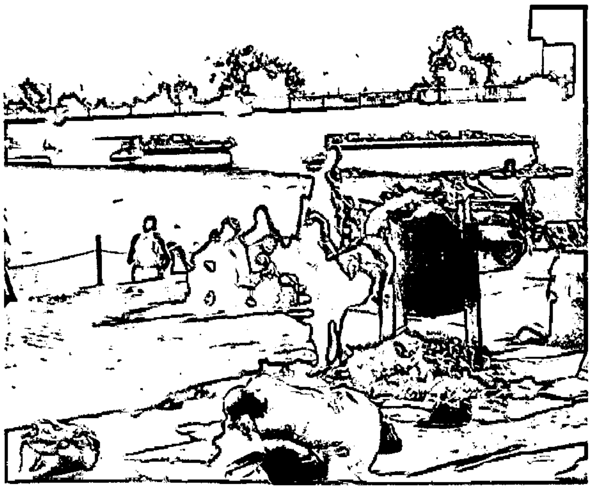
D. PLASTIC CONTAINERS



E. CONSTRUCTION DEBRIS

F. SILT ACCUMULATION

PLATE 1



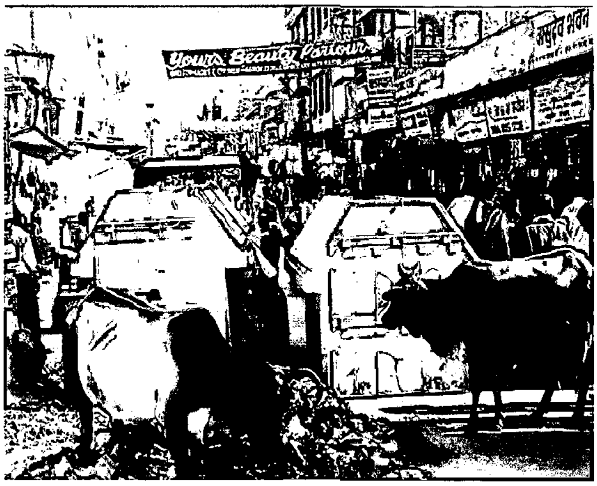
A. DRUM TYPE BIN

B. HANDCART

C. SW FROM DRAINS

D. TIPPER TRUCKS

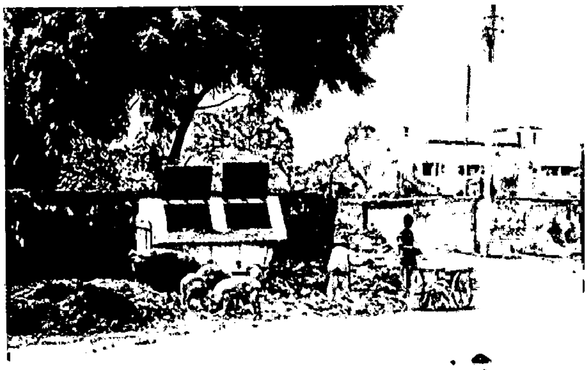
E. TRACTOR TRAILER



F. DUMPER PLACER

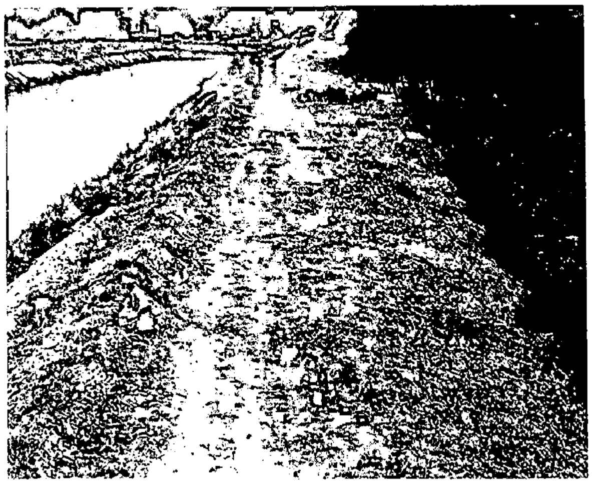
PLATE 2

A. MATERIAL RECOVERY



B. SCAVENGING

C. KABADIWALA'S DUMP



D. DISPOSAL SITE

E. OPEN BURNING

F. STREET SWEEPING

PLATE 3

5.4.4 STORAGE OF HAZARDOUS SOLID WASTES IN HARDWAR

One of the most improper and dangerous practices in the existing SWM of Hardwar is the absolute lack of any definition for the storage of hazardous solid wastes that include infective biomedical wastes, chemicals compounds from light and cottage, industries, chemicals, waste oils from automobiles.

The biomedical wastes are stored by the generators i.e. hospitals, nursing homes, dispensaries, primary health centres etc. along with other solid wastes. Thereafter, the flow of such hazardous waste is the same as all other solid wastes, till the disposal. The small and light industries operating in residential and commercial areas of Hardwar and dealing with acids, lead and other such hazardous materials, also do not have any specialized storage systems required. There are no legislative/mandatory provisions in the municipality's charter for the onsite storage of such wastes and these wastes too are being stored (where at all) and disposed by dumping on open ground or by discharging them into the sewer lines.

5.4.5 STORAGE OF ROAD SWEEPINGS, SILT AND SOLIDS REMOVED FROM SEWERS IN HARDWAR

There are no provisions for storage of road sweepings silt and the solids removed from the sewers. These are generally swept/collected by the SKs and heaped in open dumps by roadside and even on the middle of the road as high mounds of earth and waste (See Platel F). Other than the health implications, the placing of these on roadsides seriously inhibits the traffic flow through the already congested roads of Hardwar.

5.4.6 STORAGE OF WASTES BY HAWKERS, PEDLARS AND MOBILE VENDORS WITH PUSHCARTS

One of the most peculiar source of solid wastes in Indian cities are the many hawkers, peddlers and mobile vendors with pushcarts who sell different types of products including vegetables, fruits, cooked, food items, toys, crockery, clothing, kitchen ware, decorative items etc. They are an important link between producers and consumers of these items and offer products at cheaper rates than formal shops due to lower profit margins and almost no establishment cost. They are patronized by a large percentage of city populations and it is a novel way of reducing unemployment and poverty.

Hardwar too has its share of such hawkers, peddlers and vendors. Due to their mobile nature and lack of any establishment, they tend to leave wastes at or around the sites used by them for selling their products. It is commonly observed that such sellers tend to congregate at some sites, due to reasons of competition for clientele. However, the same is the cause for concentration of wastes at such locations. In the upper Road area of Hardwar, this is most conspicuous and creates malodour and visually offensive scenes of hogs and other animals feeding on such wastes.

5.5 COMMUNAL STORAGE OF SOLID WASTES IN HARDWAR

The most common method of storage of domestic, commercial, institutional and hazardous wastes are the community storage systems to which the wastes are delivered by residents or by some SWM agency, in case the community is served by door-to-door service. The communal storage of solid wastes entails the timely and regular discharge of the communities' wastes in the storage device and an equally efficient and regular collection system for collecting the wastes from the storage device. The communal storage system also implies the division of the collection system into primary and secondary collection systems. The primary collection system involves the collection of solid wastes from the generation point and transfer of the wastes to the communal storage devices. The secondary collection system involves the collection of the solid wastes from the communal storage devices and its transportation to the site for processing or final disposal.

In Hardwar the community storage systems comprise of the following:

(a) **Open Dumps** - there are 38 open dumps in Hardwar designated officially as dumping sites for solid wastes by the Nagar Palika Parishad in addition to the innumerable unofficial open dumps which exist in every nook and corner of Hardwar. Some of these open dumps are shown in Map 8. Most of these open dumps are located in or near residential areas. The areas of these dumps vary from 20 m^2 to 600 m^2. Most of these sites are accessible by collection vehicles like tipper trucks and tractor trailers, as these are located on roadsides or have roads leading up to them. Pigs, dogs, cows and donkeys infest these sites. These open sites are also subjected to scavenging by rag pickers for getting recyclable materials as well as items for reuse. These open dumps are breeding grounds for flies, vermin and other vectors of diseases (See Plate 1A).

(b) **Carrier Bins (CB)**- these are yellow/orange coloured lift able metallic containers which are lifted by tractors rigged with hydraulic lifts called Dumper Placers. The capacity of the carrier bin (CB) is 4.5 m^3, which in the context of wastes in Hardwar can take up to 1.5 metric tonnes of wastes (the average density of the waste is assumed to be in the range of 300 to 350 kg/m^3). These bins have window like openings on both longer sides, from where the waste can be placed into the bin. These openings are closed with hinged lids, during transportation. The wastes are raked out from these bins from both ends that can be opened by moving the end shutters upwards (See Plate 1B). The CBs are a safe, hygienic and proper storage device for communal storage. However in any city the capacity of all CBs together, should be adequate to store the city's waste as per the collection frequency i.e. there should be enough CBs to store all the wastes generated in the city between two collections. In Hardwar there are only 34 CBs, which cater for only 51 Metric Tonnes of the solid waste generated in the city. Thus it is inevitable that balance of the solid waste generated will be improperly stored till its removal/collection.

In Hardwar, the CBs have been placed at sites located mostly on roadsides (Refer Map 8) to facilitate lifting by the dumper placer. But unfortunately, even at these sites, wastes are littered all around the bins, although the bins may be only partially filled. At some sites, as in the Upper Road tract, the bins gets filled and more often than not, a large quantity of waste is to be found lying dumped around the bins (See Plate 1 B). In such a scenario, the conditions are akin to that of open dumps only worsened by the fact that it is on the roadside.

The CBs are carried off for disposal daily and replaced by an empty bin before being carried off to disposal sites on hydraulic lifts called Dumper Placer that is towed by a tractor. The tractor is also the prime mover for the dumper placer.

(c) **Metallic Drum Type Bins** - these are 18 to 24 inches diameter and 2 to 3 feet high metal drums that are placed at a few sites in the market areas and the Ghats of the Har-ki-Pairi. These are used by the visitors to the market and the ghats as well as the shopkeepers, hawkers etc. in the area. These are generally placed near a lamppost and secured to the post by means of a bracket (See Plate 2A). These bins are of immense use to the floating population visiting such areas, as they are prone to throwing wastes around in the absence of any storage device. Unfortunately these bins are far too less in numbers and are inadequate in capacity ever during the periods of low tourist influx.

(d) **Handcarts** - these are wheelbarrows with open metallic containers used by the Safai Karmacharis (SKs) for transporting wastes from open dumps to collection points of collection vehicles (See Plate 2B). But when the SKs leave their handcarts in their area of responsibilities, especially in narrow lanes and high-density residential areas, the residents started placing their wastes in the handcarts to avoid littering of wastes on narrow lanes and access roads. This arrangement works fine for both SKs and residents, both of whom tend to benefit from the practice. The SKs do not have to pick all wastes from the open dumps (thus reducing some manual handling of wastes) and residents do not have to store wastes in their premises. However, some littering of wastes by animals and scavengers still takes place.

5.6 COLLECTION OF SOLID WASTES IN HARDWAR

The collection of solid wastes in Hardwar is wholly the responsibility of the Sanitation Department of the Nagar Palika Parishad (NPP), Hardwar. It is carried out using the manual and mechanical means under the aegis of the Chief Food and Sanitary Inspector. In Hardwar as per the C.F.S.I., the average solid waste collected by his department on a non-monsoon season day is 162 Metric tonnes leaving 9 Metric Tonnes (MT) of solid wastes uncollected. When questioned about the final disposal of this 9 MT of solid wastes, the C.F.S.I. attributed the disposal of this large quantity of solid waste to dispersal by winds and blowing onto the canal and river, which further carries away the wastes.

The functional element of collection, as used in this paper, in the context of Hardwar includes not only the gathering of solid wastes, but also transport of these wastes, after collection to the location where the collection vehicle is emptied. In the context of Hardwar this location may be any of the following:

(a) Open dumps

(b) Carrier Bins/Dalaos

(c) Disposal site

Since Hardwar is a small city, the final disposal site is nearby and therefore the hauling of wastes is not a serious problem although there too the means and methods are deficient as discussed under transportation of wastes.

The collection of Solid Wastes in Hardwar comprises mainly of the following operations:

a) Collection of wastes from residential areas of Hardwar.

b) Collection of wastes from commercial and institutional areas of Hardwar.

c) Collection of wastes from public areas like bus stop, railway stations, roadsides, temple premises ghats.

d) Collection of Construction and Demolition Debris

e) Collection of Hazardous wastes.

In Hardwar, the collection activity is carried out 6 days a week, with a weekly day off on Wednesday. Also, on all gazetted holiday and restricted holidays of NPP Hardwar, there is no collection of wastes carried out. Thus in a year, solid wastes are not collected on approximately 70 days, which amounts to 11970 MT of solid wastes, if the lowest generation quantity of non monsoon season is taken into consideration.

5.6.1 COLLECTION OF WASTES FROM RESIDENTIAL AREAS

There is no system of door-to-door collection in Hardwar. The residents generally follow one or more of the following methods to discharge their wastes to open dumps/CBs/handcarts/dalaos:

(a) The residents themselves bring their solid wastes to the stationary container i.e. dalao and open dump or to the portable CBs or handcarts depending on which is the nearest available facility.

(b) The residents have their servants carry the wastes and dispose the same into the most convenient communal storage facility.

(c) The residents/ the servants throw the wastes onto the roadside/street/open space/vacant plots etc. The SKs then pick up the wastes from there using short handled shovels/brooms and a large metallic *bowl like vessel* called "*tasla*", and put it into the open handcarts. Sometimes wastes are also thrown into the open drains/nalas from where it is removed by SKs when it chokes the drains and placed by the side of the drains. The waste is then brought to the nearest communal storage facility and discharged into it by the SKs.

When the collection vehicles comes to collect the waste from the communal storage facility, the SKs who accompany the collection vehicles again gather the waste from the ground/dalao using shovels and tasla and load it onto the trucks or trailers (See Plate2 D and E) and after loading the wastes, move on to the next dumping site. Once the tipper or trailer is filled, the vehicle moves to the disposal site directly. On reaching the disposal site the tipper trucks unload the waste by tipping. In the case of tractor-trailers, the SKs unload the trailer manually by raking the wastes with a rake and by lifting the wastes with a shovel and throwing it on open ground.

In areas where CBs are placed for communal storage, the SK accompanying the Dumper Placer picks up the wastes littered around the bin and places it in the bin and closes the openings. The tractor driver aligns the Dumper Placer and reverses the tractor to bring the Dumper Placer under the bin. Thereafter, the bin is lifted by the hydraulic lift and carried away. Generally, the last bin that was emptied on previous day is brought to the site of first bin to be collected and placed there before carrying off the loaded bin disposal. Then the vehicle returns to another loaded bin site with an empty bin to replace the loaded bin and so on.

Solid waste collection is a free service provided by NPP and there is no door-to-door collection from residential areas in Hardwar and it is up to the citizens to discharge their solid wastes to communal storage facilities. But during the author's field survey, it was revealed by a number of residents of Govindpuri and Awas Vikas that they paid a monthly fee of Rs.10/- to Rs.5/- to the SKs who work in these areas. Although all the residents were aware that the collection service is provided free by the NPP, they had to pay the SKs because that ensured regular removal of wastes from the bins, roadsides, open area and vacant plots in these areas. Also, due to this payment the SKs do not throw the wastes into the drains and manholes, thus keeping these flowing and clean. It is presumed that SKs in other residential areas would also be indulging in similar practice. Thus these SKs who are paid employees of NPP, Hardwar, are unofficially taking money for doing their job.

5.6.2 COLLECTION OF WASTES FROM COMMERCIAL AND INSTITUTIONAL AREAS OF HARDWAR

The collection of wastes from commercial and institutional areas of Hardwar is similar in nature to collection of wastes from residential areas. Most commercial and institutional establishments dump their solid wastes either into the communal storage facilities and when that is not near enough the wastes are thrown into the drains/manholes or on vacant plots, open spaces or roadsides etc.

The wastes from roadsides, street corner, open spaces, vacant plots etc picked up by the SKs using short handled brooms, shovels and tasla and put into handcarts and carried to open dump/carrier bins/dalaos serviced by collection vehicles and dumped there.

Where the wastes are thrown into the drains, it accumulates till the drains get choked and then the SKs remove the wastes from the drains and heap them on the roadside along the drains (See Plate 2C). When these heaps become a nuisance due to malodour and ugly sight these are again collected by the SKs in handcarts and carried to communal storage sites serviced by collection vehicles.

There are some areas, which are directly serviced by collection vehicles such as Ranipur More, some parts of the Upper Road, Jwalapur and Kankhal. In these areas the collection crew of the collection vehicle pick up the wastes heaped on both sides of the road (using shovel and tasla) and load it in the vehicle and the vehicle keeps moving on its route.

The commercial and institutional areas where carrier bins (CBs) are available for communal storage, these are collected, emptied and replaced by empty bins one by one in a cyclic manner. The CBs are taken to disposal site directly and wastes unloaded by the SK by raking out the wastes with a long handled rake.

A very interesting phenomenon is noticed in the case of collection of wastes from big restaurants, hotels and dharamshalas along the routes of collection vehicles. The collection vehicles stop at these restaurants, hotels and dharamshalas and the solid wastes from these are brought out by the establishment staff in plastic and metallic containers and handed over to the collection crew for loading onto the collection vehicles. On enquiring about the reasons of such preferential service, it was revealed by the establishment staff and the SKs that these establishments pay to the tune of Rs.100/- to Rs.150/- per month to the driver and collection crew of the collection vehicle. However, as per the NPP this is a free service for which no charges are being levied by the NPP. Thus the SKs are collecting a considerable amount of money from such commercial establishments. Such practices tell us why payment by the generators for the service of SWM should be made legal.

5.6.3 COLLECTION OF WASTES FROM PUBLIC AREAS

The public places like markets, bus-terminus, railway stations, temple premises, ghats have little or no storage facilities in Hardwar. Where the storage facilities like carrier bins, dalaos or even drum type bins are available they are serviced by collection vehicles or SKs with handcarts.

Wherever such storage facilities do not exist the collection operation is primarily sweeping the wastes into heaps, then manual lifting into handcarts, carriage to a communal storage site and discharging the wastes onto the storage facility whether it be carrier bin/dalao/open dump along routes of collection vehicles (See Plate 2 F).

The wastes are further collected from these storage facilities by the crew of collection vehicle and transported to disposal site and dumped there.

It is pertinent to mention here that the public areas, frequented most by the large floating population in Hardwar, are the least organized for storage and collection of solid wastes. Very few bins are placed in the market areas, various temple premises and on the ghats.

5.6.4 COLLECTION OF CONSTRUCTION AND DEMOLITION DEBRIS

There is no separate collection arrangement for construction and demolition debris in Hardwar. Most of the construction debris is dumped by the generator outside his premises on any available land including roadside, open space, vacant plot and most commonly at open dump sites for solid wastes (See Platel E).

From the open dumps the SKs load the construction and demolition debris, along with the solid wastes, onto the collection vehicle and transport it to the disposal site for dumping with other solid wastes.

During discussions with a number of builders and the C.F.S.I., Hardwar it was discovered by the author that the builders pay a small amount to the driver and collection crew of collection vehicles for collecting the construction and demolition debris from their construction site and disposing it at the disposal site for solid wastes. The large quantity of construction and demolition debris, which was observed by the author at the disposal site testify this information.

5.6.5 COLLECTION OF HAZARDOUS WASTES IN HARDWAR

The hazardous wastes in Hardwar are generated mainly from the many medical institutions (such as hospitals, nursing homes, primary health centres, dispensaries etc.) and the light and cottage industries generating chemical compounds. However, there is no arrangements for separate collection of these hazardous solid wastes which not only pose a threat to the SKs who handle these wastes but are also potent pollutants and contaminants for ground, air and water and more to due to incorrect disposal practices.

It has already been discussed in Chapter 2 and 3 that a major portion of Solid Wastes Management expenditure is spent on the collection of Solid Wastes. This it true for both developed countries as well as India, although in the developed countries the process is highly automated and employs sophisticated technology and in India, the stress is more on manual methods.

In the case of Hardwar, although no accurate breakdown of expenditure was available as per the C.S.F.I., Hardwar, his department spends 85 to 90% of the funds allocated for Solid Waste Management for collection and which includes the following:

a) Pay and allowances of all staff engaged in collection.

b) Operations and maintenance cost of vehicles and equipment used in collection.

5.6.6 VEHICLES AND EQUIPMENT USED FOR COLLECTION OF SOLID WASTES IN HARDWAR

As per C.F.S.I., Hardwar, the total solid wastes collected per day is 162 Metric Tonnes (MT), out of the total 171 MT generated per day, leaving 9 MT uncollected per day. Based on these figures the collection efficiency achieved is almost 95%. However, as per the author's study of the SWM practices in Hardwar from the point of generation to the final disposal, at no stage is the existing infrastructure for SWM in Hardwar adequate enough for handling 170 (MT) of solid wastes. The collection vehicle fleet of the NPP, Hardwar, is small and inadequate. A good number of the equipment is lying unused due to lack of resources for repairs. Some of the equipment, which were bought for SWM are utilised for other activities related to urban management and some redundant equipment are also lying unused with the Solid Waste Management and Surface Sanitation Department.

The various types of vehicles and equipments used for collection of solid wastes in Hardwar (See Plate 2 D,E,F) and their collection capacities is given in Table 5-3.

Type of Vehicle/ Equipment	Nos.	Capacity (in Metric Tonnes)	Crew	
			Driver/operator	Collection crew
Tipper Trucks	06	03	01	02
Tractor Trailers	07	02	01	02
Carrier bins (CBs)	34	1.5 (4.5 cu.m.)	01	01
Handcarts	148	0.1	-	01
Dumper Placers for CBs	02	01 CB	01	01
Loaders	04	0.5	01	-
JCB	01	0.5 (for loading & Dozing)	01	-
Sewer Cleaning Machine	03 (Each comprising of 02 units)	-	01	01

TABLE 5-3: EQUIPMENT AND VEHICLES USED FOR COLLECTION OF SOLID WASTES
(Source: C.S.F.I., P.H. & S. Deptt, NPP, Hardwar)

From the table it is obvious that in Hardwar tipper trucks, tractor-trailers and carrier bins are the primary means of transportation of the solid wastes from the communal storage facilities to the final disposal site. If we consider the functioning of the collection vehicles and equipment available with the C.F.S.I. and work out their carrying capacity we find that it is inadequate for transportation of the wastes generated in Hardwar. The generalized details of collection trips made by the vehicles and equipment involved in collection are given in the table 5-3 below.

Type of Vehicle/Equipment	Length of each trip (Km.)*	Time taken for each trip(Hr.)@	Total SW load carried per day (MT)
Tipper trucks	25-30	2.5-3.0	36-54
Tractor trailer	20-25	3.0-3.5	28
Carrier Bins	8-10	0.5	51
Handcarts**	1-2	1.0-2.0	-

TABLE 5-4: DETAILS OF COLLECTION TRIPS
(Source: Physical survey and enquiry by author)
*from collection area to disposal site and back
@roundabout time for above journey
**disposal to communal storage site.

As per the C.S.F.I. the tipper trucks make 4 to 6 trips and tractor-trailer make 3 to 4 trips a day. This is obviously incorrect since 4 trips of tipper truck in eight hours working period would include the time for loading of 12 Metric Tonnes by the collection crew of two SKs, travelling time, and tipping time or disposal site and lunch time. So it is indeed a very difficult proposition for tipper trucks that are manually loaded, to make more than 03 trips in a day. In the case of tractor-trailers, the travelling speed is lesser than that of tipper trucks and each trip takes longer than that for tipper truck and thus, in reality the tractors with trailer are able to make only two trips in day.

Based on the above facts, if we consider the total quantity of Solid Wastes that can be collected and transported to disposal site by the vehicles it comes to 133 Metric Tonnes. This capacity implies 100% vehicle usage and no breakdown etc. of the entire fleet, which again is very difficult to sustain over long periods of time and is highly improbable. Also in the present scenario of lack of resources for maintenance, repairs and upkeep of vehicles and equipment in the NPP, Hardwar, it is unlikely that more than 75% of the fleet and equipment is operational. In light of the above, it would be pragmatic to presume that the projected quantity of wastes generated and collected, is grossly exaggerated by the C.F.S.I., Hardwar.

5.7 TRANSFER AND TRANPORTATION OF SOLID WASTES IN HARDWAR

In the field of SWM, the functional element of transfer and transport refers to the means, facilities, and appurtenances used to transfer the wastes from one location to another, usually to more distant location. Typically the contents of relatively small collection vehicles are transferred to larger vehicles that are used to transport the waste over extended distance either for processing or to disposal sites. Transfer and transport operation become a necessity when haul distances to available processing centres or disposal sites increases such that direct hauling is no longer economically feasible. They also become a necessity when processing centres or disposal sites are sited in remote location (Tchobanoglous, et el 1993).

5.7.1 TRANSFER OPERATIONS IN HARDWAR

In the case of Hardwar, the small extent of the city, the lack of any processing facility for solid wastes and the proximity of the present disposal site deviate the need for any formal large-scale transfer operations. However, as explained earlier, the transfer of wastes from handcarts to communal storage facility forms the small-scale transfer operation.

The solid wastes are collected in handcarts by SKs from areas that are inaccessible for the collection vehicles (like tipper trucks and tractor trailers) and where even carrier bins cannot be placed for communal storage due to paucity of space. These wastes are then brought to the communal storage sites, which include open dumps, dalaos and carrier bins.

The SKs then transfer these wastes to the carrier bins with the help of basket/tasla and shovel and in the case of dalao or open dump by overturning the handcart. From these communal storage systems, collection vehicles again collect wastes, as explained in Section 5.5.

In future when processing of solid wastes is necessitated both by law and the economic compulsions, of recovery and recycling of materials and recovery of energy, then the large scale and formal transfer operations are liable to be incorporated within the framework of SWM.

5.7.2 TRANSPORTATION OF SOLID WASTES IN HARDWAR

In the existing SWM practice of Hardwar, the functional element of transportation is dovetailed into the collection process as the very collection vehicles are also used for transportation of the solid wastes from collection points to the disposal site. The primary reason why separate transportation vehicles are not required is the close proximity of the present disposal site to the city. Basically, it is advantageous as the infrastructure for transfer and transportation and its maintenance and operation would have been a further drain on the finances of the NPP, in the present management scenario where no formal recovery/recycling operations are undertaken. For future needs transportation of wastes to faraway sites by railways is also a possibility.

5.8 SOLID WASTES PROCESSING AND RECOVERY OPERATIONS IN HARDWAR

There are few cities in India where any formal processing and treatment operations are practiced for solid wastes before their disposal in open landfills/sanitary landfills as discussed in Chapter 3. In the city of Hardwar too, commingled wastes containing many recyclable materials as well as toxic and hazardous components are not subjected to any sort of organized processing or treatment before disposal. There are no plants/units for segregation and recovery of materials or energy in Hardwar, and there are no benefits to the NPP, Hardwar from the wastes collected, transported and finally dumped in the disposal area by the NPP authorities.

Other than the sorting, segregation and removal of certain items like plastic, glass, metal, cardboard, leather and wood by the scavengers and rag pickers, the commingled solid wastes in Hardwar are not subjected to any other form of processing or treatment before disposal.

The hazardous wastes from all sources, the biodegradable wastes and the non-biodegradable wastes are all collected and disposed off together. The treat potential/ill-effects of the commingled solid wastes are not reduced/alleviated by the smallest of measures, it is only distanc4ed from the source in an "out of sight, out of mind" syndrome by taking it across the Ganges, over the Chandi Ghat bridge and dumping it along the Eastern Ganga Canal.

Physical survey by the author has established (See Plate 3 A,B) that there is an active and thriving informal recycling industry in Hardwar which is recovering reusable materials from the waste dumps and recycling many such items into the markets in Hardwar and elsewhere.

5.8.1 THE ROLE OF INFORMAL SECTOR IN PROCESSING AND RECOVERY

An informal recycling industry is operational in Hardwar, just as in any other Indian city. As per the Chief Food and Sanitary Inspector an estimated 250 to 300 rag pickers and scavengers work in the city's open dumps, bins and the disposal sites, collecting plastic, paper, glass and metal and wooden items for sale to the city's "Kabadiwalas" or the scrap merchants (See Plate 3C).

There are approximately 20-25 kabadiwalas in the city dealing in plastic, paper, glass, metal and wood. The rag pickers and scavengers collect on an average 30 to 40 kg of recyclable materials per day and sell it to the kabadiwalas.

Another source of recyclable materials for the scrap merchants or kabadiwalas is the Itinerant Buyer (IB) who buys the recyclable material including old newspaper from the households directly. The Itinerant Buyer (Raddiwala in common parlance) then sells these to the Scrap merchant for further disposal.

The segregated, recyclable materials are then transported by the kabadiwalas, by road, to the various industries that use these as raw materials. These industries are located at Muzzafarnagar, Saharanpur and Meerut.

The total quantity of material recovered by the rag pickers from the garbage of the city is in the range of 8 to 10 metric tonnes per day. Even at a very low average cost of these materials the economic value is considerable and thus we find a significant number of people involved in the informal recycling industry in Hardwar. The resource potential of the solid wastes in Hardwar is discussed in Section 6.12.

5.9 SOLID WASTES DISPOSAL PRACTICES IN HARDWAR

As discussed in earlier chapter, irrespective of the processing and treatment that the solid wastes and subjected to there will always remain a portion, which has to be finally disposed by landfilling. In the absence of any processing and treatment operations, as in the case of Hardwar's solid wastes, the entire quantity of commingled solid wastes collected has to be disposed in the landfill. In either case, the landfill has to be an engineering construction meticulously planned, carefully designed and flawlessly executed to prevent any adverse effect on the land, air and water in vicinity.

5.9.1 THE PRACTICE OF OPEN DUMPING IN HARDWAR

In Hardwar all the solid wastes collected by the SKs from the city, are brought across the Chandi Ghat bridge and dumped in the low lying area, adjacent to the Eastern Ganga Canal (Refer Map 8) on the banks of river Ganges, on land belonging to the Irrigation Department.

As discussed in earlier sections, there is no separate collection system for hazardous wastes in Hardwar and the same goes for the disposal of the hazardous wastes too. The hazardous wastes of Hardwar are also dumped along with all other wastes by the bank of river Ganges and adjacent to the canal.

The low-lying area adjacent to the canal is approximately 1.5 km long and varies in width from 75 to 150 metres. This site has been in use for disposal of solid wastes, as well as animal carcasses and animal wastes from slaughterhouses, for the last 3 years and as per the C.S.F.I., Hardwar it is planned to use the site for another 2 years.

The disposal site is accessible by the service truck of the canal. Presently there is heavy undergrowth of shrubs and bushes in the area but the vegetation is being slowly immersed in the wastes of Hardwar.

There is no monitoring facility at the disposal site to monitor the dumping and the vehicle drivers and SKs are dumping wastes as per then whims and fancies.

The site does not have any fencing/boundary wall to prevent ingress by scavengers and animals. Thus it is quite common to see both animals and scavengers in the disposal sites (See Plate 3 D).

Facilities for monitoring leachate and gas emission from the open dump do not exist. Although the water of Eastern Ganga Canal is distributed for agriculture even the irrigation department is not disturbed by the threat of ground and surface water pollution due to leachate from the open dumps of solid wastes disposed along the Canal. There is no arrangement for protective measures like impervious lining materials, cover material etc to protect the waters of the canal against pollutants from the open waste dumps.

Another polluting disposal practice at the site is the rampant open burning of all the wastes after they have been dumped (See plate 3 E). The SWM authorities are organising open burning of the solid wastes oblivious of the air pollution caused by toxic gases emitted due to burning to plastics, rubber and other chemicals.

To sum up, the disposal practice of Hardwar's Solid waste Management system is not only a source of intense pollution but also a hazardous operation for the people and the environment of Hardwar.

5.10 ANALYSIS OF THE EXISTING SWM PRACTICES IN HARDWAR

Having surveyed and studied the existing Solid Waste Management practices in Hardwar we have been able to identify the incorrect practices and the manifestation of problems due to these improper practices. However there are many other causes, which go a long way to create conditions for the improper practices to continue, in spite of problems created by them. Some of these are our own making and others prompted by forces of nature. However no problem is insurmountable given the will to do so exists. These issues are discussed below to get an insight into the problems of the SWM practices in Hardwar and their causes.

5.10.1 THE EFFECT OF URBAN SETTING OF HARDWAR ON SWM PRACTICES

Various factors like mixed landuse pattern, high population density, climate, restricted access to households in core areas, heavy traffic conditions and land availability for disposal needs have a significant effect on the solid wastes management in a city. In the case of Hardwar the following facts were observed during various surveys:

a) High density residential areas with confined living quarters and there is little or no yard space available for waste storage bins especially in the city core i.e. Har Ki Pauri and Moti Bazaar area.

b) The warm topical climate and the high seasonal rainfall affect storage and collection arrangements for wastes.

c) The city core area is characterized by houses which are accessible only by narrow walkways

d) The large number of slums and squatter settlements has haphazard and extremely narrow unpaved foot-tracks used for internal circulation.

e) The circulation of traffic within the city is slow due to inadequate road widths, encroachments on roads, parking of vehicles on road, presence of slow moving traffic like horse-carts, bullock-carts, rickshaws etc.

f) Very little land available within the municipal area that can be used as disposal site.

Due to the above mentioned urban characteristics of Hardwar city the following inferences/considerations for sustainable SWM in Hardwar must be borne in mind:

a) Collection frequency in density populated areas of the city has to be daily because the waste content is highly organic and warm temperatures lead to rapid decay of the wastes and consequent insects, vermin and pests propagation.

b) Collection frequency in the core area has to be daily also because space for waste storage on residential, commercial and institutional premises is invariably severely constrained.

c) Manual pushcarts/wheel barrows are easiest mode of access and collection in congested areas with narrow lanes.

d) A judicious mix of manual and mechanical collection equipment has to be used based on the circulation area available in various areas.

e) Collection timings for primary and secondary collection have to be organised to achieve optimum efficiency of manpower, vehicles and equipment.

5.10.2 PROBLEMS/DEFICIENCIES OBSERVED IN THE EXISTING SOLID WASTE MANAGEMENT SYSTEM OF HARDWAR

On studying the existing SWM in Hardwar, we find the rampant manifestation of the problems, due to the inadequate and inappropriate practices. Right from the point of generation to the point of final disposal, we find many occasions when the faulty practice becomes the very source of pollution and hazard that it is supposed to prevent. Although most problems appear to have different immediate effects, the most important aspect is the threat posed to the human, animal and plant lives, and the environmental degradation due to the pollutants from the solid wastes. Some of the glaring problems that emerge out of the study and survey of Hardwar are listed below.

I. Problems Observed At Or Near Generation Points of Solid Wastes

1. Dumping of wastes on roadside, vacant plots, open spaces, drains and around bins/dalaos.

2. Dumping of animal dung along with solid wastes.

3. Biodegradable and non-biodegradable wastes dumped together.

4. Open burning of wastes in public places and on roadsides.

5. No door-to-door collection in either residential areas or commercial areas.

II. Problems Observed At Or Near Community Collection Points-Bins/Dalaos

1. Littering around bins/dalaos.

2. Overflowing bins/dalaos.

3. Dalaos without roof/ open bins.

4. Defecation by people around bins/dalaos.

5. Presence of rag pickers, scavengers and animals inside dalaos/bins.

6. Dumping of animal carcass and animal dung in bins/dalaos.

III. Problems Observed In The Collection Process

1. Unsuitable waste carrying equipment for *Safai Karmacharis* (SKs) like wicker baskets, *tasla* etc.

2. Multiple manual handling of wastes.

3. Handling of wastes with incorrect tools and implements like small handled shovel, spades etc.

4. No protective hand and footwear for SKs.

5. Collection of wastes in open handcarts, tipper trucks and tractor trailers with no provisions for cover.

6. Inappropriate loading height of waste carrying vehicles.

7. Littering of wastes during loading.

8. Low collection efficiency-uncollected waste left in open dumps/dalaos even after collection.

9. Collection during hours of peak traffic movement-from 8 a.m. To 5 p.m.

10. Open burning of wastes by collection crew in public places and roadsides.

IV. Problems Observed In The Process Of Transportation

1. Transportation of wastes in open trucks, trailers, handcarts etc.
2. Littering of wastes on roads from vehicles in transit.
3. Routes of transportation through congested and crowded areas during peak hours of traffic.

V. Problems Observed In The Processing And Recovery Operation

1. No formal processing and recovery units.
2. Recovery and recycling activities restricted to small and medium kabadiwalas.
3. Involvement of small children and old people in collection of recoverables from dalaos and bins.
4. Small children and old people employed for sorting and segregating wastes.
5. No protective clothing for rag pickers/ scavengers.
6. Financial implications of recovery and recycling not considered for working out economics of SWM.

VI. Problems Observed In The Disposal Process

1. Open dumping of wastes on low-lying ground just besides the eastern Ganga canal.
2. Site accessible to rag pickers/scavengers and animals.
3. Dumping of animal carcass at disposal site.
4. Open burning of wastes at disposal site.
5. No pollution control measures.
6. No monitoring of waste disposal activities.

7. Hazardous wastes-chemicals and biomedical, also being dumped at the same site.

5.10.3 SOME OF THE CAUSES ATTRIBUTABLE TO THE PROBLEMS

Some of the causes that can be attributed to the problems that are manifest as discussed in the preceding section are:

1. Lack of literacy and education amongst the public.
2. Lack of concern among the educated and illiterate, alike, for the environment.
3. Inadequate and improper utilization of resources available with the urban local body due to which adequate service cannot be provided to the population.
4. Inefficient and improper planning and management of the urban services by untrained personnel.
5. Corruption within the ranks and file of the Nagar Palika Parishad, Hardwar.
6. Lack of any suitable legislation regulating the SWM activities of the NPP, Hardwar.
7. The lack of legislation to regulate public behaviour and participation in the process of SWM in Hardwar.
8. No environmental standards/requirements/checks to control the malpractices in SWM operations.

It is important to note that the causes for each of the problems as well as the problems themselves are not independent of one another. If we take the problems one by one and trace their causes we get an interconnected network of causes and effects of problems. Fig 5-1 shows a representation of partial network of cause effect of solid wastes management problems in Hardwar.

PARTIAL CAUSE EFFECR

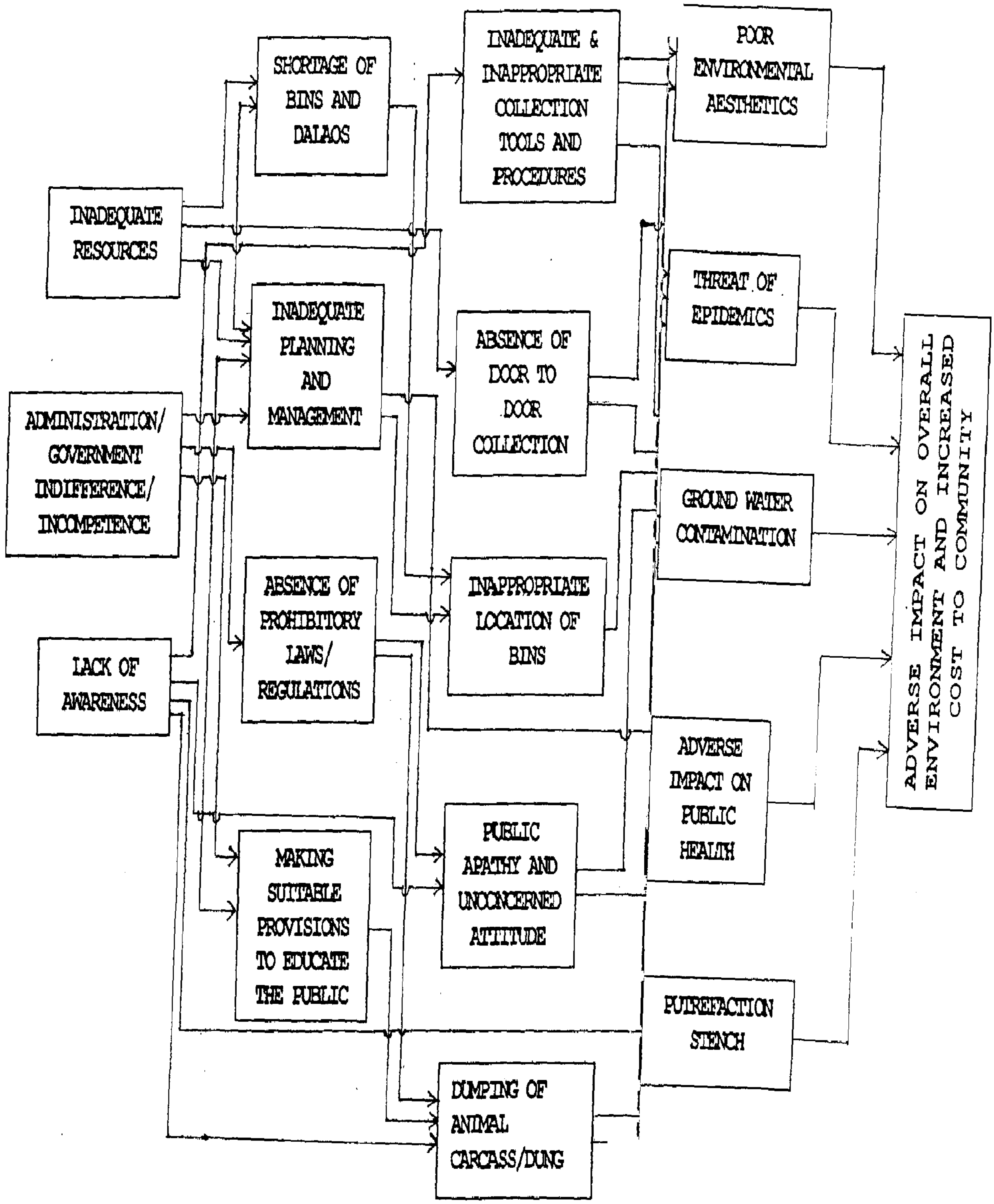


FIGURE 5-1: PARTIAL CAUSE EFFECT NETWORK OF SO...

CHAPTER 6

PROPOSALS FOR SUSTAINABLE SOLID WASTE MANAGEMENT IN HARDWAR

6.1 GENERAL

One of the largely unrealised shortcomings of mankind has been to attribute undue importance to the act of consumption in defining and constructing the magnificence and beauty of cities it has created. However in the brilliant process of creation of the city as an act of consumption, man has invariably ignored the act of excretion. To sustain the beauty of the cities and to keep their environment suitable for habitation it is essential to dispose off their wastes in a scientific and most economical manner so that the waste disposal process itself remains a viable option for the city.

Hardwar situated below the Shivalik ranges and spread out along the holy river Ganges is one such living entity which has to it the function of waste generation as much as any other. As such it is pertinent to evolve a sustainable system to take care of the solid wastes generated within the city.

It has been the objective of this dissertation to define a solid waste management system for Hardwar that would be technically feasible, economically viable, and socially acceptable. The stress has obviously been on finding out the deficiencies and malpractices in the present system and the causes to which they are attributable. Thereafter the exercise of solution finding has been based on the premises of optimisation of resource utilization, recovery of expenditure incurred by the municipality on SWM from the beneficiaries, and implementation of easily applicable measures within the existing framework. Finally phasing of attainable objectives to improve the SWM system and bring the practices to the desirable standards have been suggested.

The management of SWM in a city cannot be considered in isolation. It must be seen in the context of socio-economic as well as infrastructure problems posed by the rapid urbanization and population increase that the city experiences.

6.2 THE BASIC PARAMETERS OF SUSTAINABLE SWM

The foremost parameter for the sustainability of SWM is that the system should be inherently economically viable. It is important for any service of this nature to be economically viable as the dependence of the service totally on budgetary allocations, grants and aids leave the service prone to malfunctioning or lowering of standards in the absence of such allocations.

The criteria of inherent economic viability implies that the system has to cater for its financial requirements itself. In the case of a service like SWM this can easily be achieved by making the generators of wastes (who are also the beneficiaries of the service) pay for the expenditure incurred in collecting, transporting, processing and disposing the wastes. This incidentally, is one of the draft recommendations of the National Workshop on Solid Waste Management held by the Ministry of Urban Affairs and Employment, Government of India, in collaboration with World Health Organization in New Delhi in 1995.

The second parameter is the control/regulation of all the functional elements of SWM system as per the standards and each of their stages with comprehensive and enforceable legislation. This also includes incorporation of an implementation mechanism of the relevant laws within the SWM framework. Very strict and stringent punitive

PARTIAL CAUSE EFFECT NETWORK OF SOLID WASTE MANAGEMENT IN HARDWAR

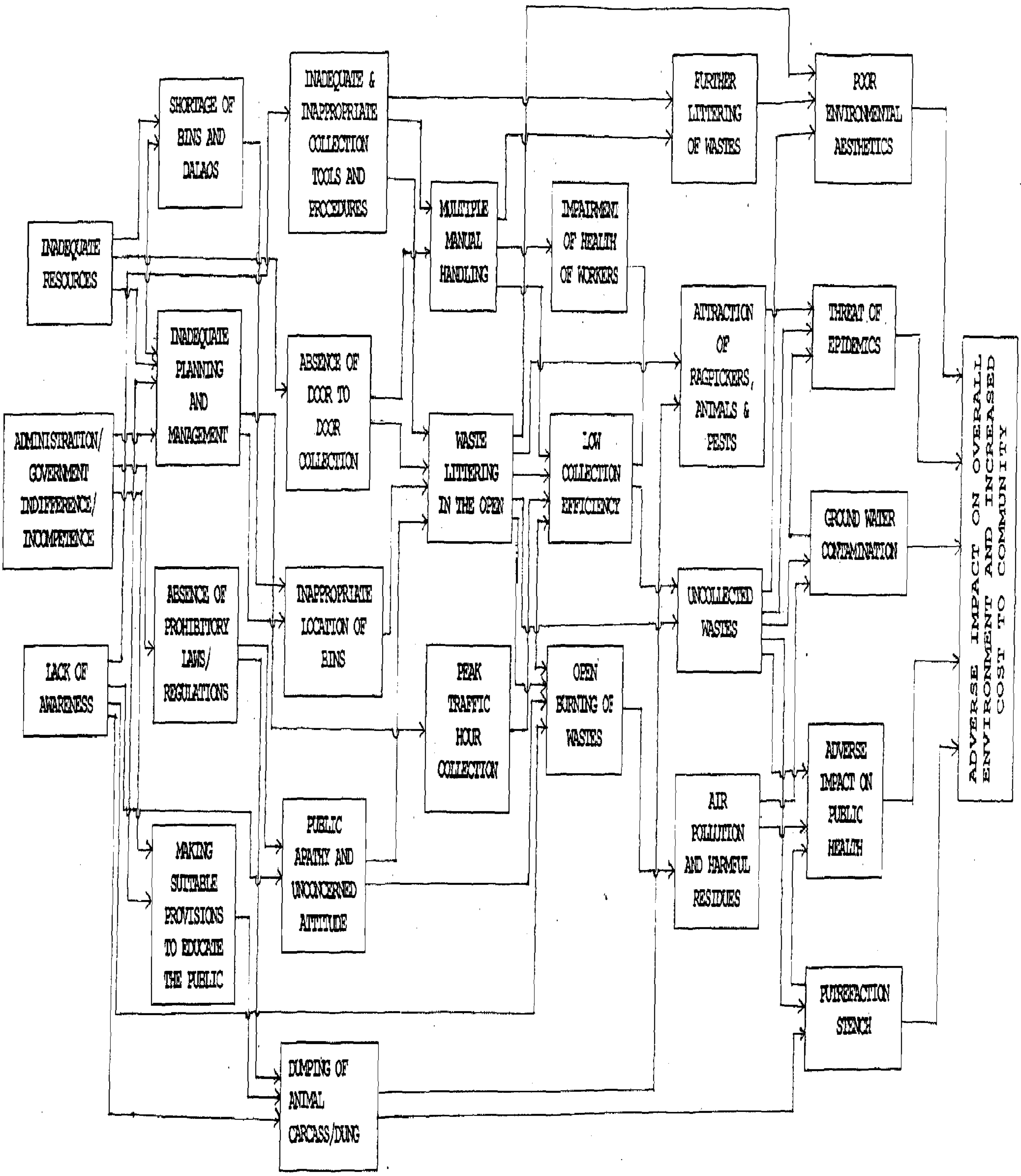


FIGURE 5-1: PARTIAL CAUSE EFFECT NETWORK OF SOLID WASTE MANAGEMENT PROBLEMS IN HARDWAR

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The second parameter is the control/regulation of all the functional elements of SWM system as per the standards and each of their stages with comprehensive and enforceable legislation. This also includes incorporation of an implementation mechanism of the relevant laws within the SWM framework. Very strict and stringent punitive measures have to be spelt out to render difficult the violation of these laws/regulation.

Another important parameter for making the SWM operation sustainable is the formalisation of the recovery and recycling operations. Recycling in most Indian cities is predominantly in the hands of informal sector entrepreneurs, who at the lowest levels live in the slum and squatter settlements and perform their work in the refuse dumping grounds of the cities or even in the bins, dalaos and open dumps before the refuse is collected for disposal. There is no recognition of the trickle up economic effect derived from direct informal sector recycling whereby municipal costs for refuse disposal are reduced, private sector jobs are created and precious energy in manufacturing is saved through the use of recycled materials. Where such formalisation is not yet feasible, the municipalities should encourage the recycling operations by the informal sector by stream - living the recycling procedures, providing adequate service to protect the workers health and organizing the market for recovered materials.

6.3 THE PROPOSED SWM PLAN EXPLAINED

The proposed SWM plan for Hardwar has been worked out for each of the six functional elements in a systematic approach within the framework provided by the above mentioned parameters. The first of the elements to be covered is the generation of the solid wastes in Hardwar.

Benchmark data considered for various calculations are given below:

(a)	Permanent population	=	2,35,074
(b)	Average size of households	=	5
(c)	Total number of households	=	47,015
(d)	Number of HIG households(20%)	=	9403
(e)	Number of MIG households(30%)	=	14,105
(f)	Number of LIG Households(50%)	=	23,508

(g) Total floating population = 1,00,000/day

(h) Total area of the Municipality = 12.78 sq km
For which proposals made

6.4 SOLID WASTE GENERATION RATES IN HARDWAR

We have already discussed the solid waste generation rates and the quantity of solid wastes generated in Hardwar. As per the Report of the Committee constituted by the Hon. Supreme Court of India, March 1999, the average solid waste generation rate in Hardwar should be approximately 210 grams per capita per day (Refer Table 3-2). If we consider the generation rates in a metropolitan city like Delhi, 450 grams per capita per day has been taken as the planning figure for 1998, by the MCD and NEERI (Refer Table 3-10). Taking the above two figures of generation rates, it is evident that the generation rate in Hardwar is unlikely to be as high as 600 grams/capita/day as given by the C.F.S.I., Hardwar.

In the absence of any method to measure the generation rates/quantity of sold wastes generated in Hardwar, a logical assumption will have to be made for the solid waste generation rate. The most important criteria that has to be kept in mind for arriving at a planning figure for the generation rate is the increasing consumption pattern of the society. With the advent of market economy and the increased quantum of tourist influx in Hardwar the retailing and trading activities have increased manifold, leading to increased generation of solid wastes. Also the generation rate is likely to increase further as the population of the city increases over time. To keep the SWM facilities at a convenient scale we assume the following rates as applicable presently for planning of SWM in Hardwar:

(a) For permanent population : 500 grams/capita/day

(b) For floating population : 300 grams/capita/day

In addition to the generation rates, two other baseline assumptions have been made in respect of the generation rates, to simplify the complexity of the calculations and also to get over the lack of factual data regarding the operative parameters of the SWM practices in Hardwar.

(a) 80% of the per capita waste generated by the permanent population is generated in the households and 20% is generated in public places like commercial areas, institutional areas etc.

(b) All solid waste generated by the floating population is generated in public places like commercial areas, institutional areas, places of tourist interest etc.

1. TOTAL SOLID WASTES GENERATED IN HARDWAR

SW generated by the permanent population :		2,35,074 X 500 gm
@ 500gm/capita/day	=	117.537 MT/day
SW generated by the floating population	:	1,00,000 X 300 gm
@ 300gm/capita/day	=	30.000 MT/day
Total SW generated in Hardwar	:	147.537 MT/day
(say)	=	**148.00 MT/day**

2. TOTAL SOLID WASTES GENERATED IN HOUSEHOLDS IN HARDWAR

SW generated in Households by permanent	:	2,35,074 X 400 gm
population @ 80% of generation rate	=	94.0296 MT/day
i.e. 400 gm/capita/day **(say)**	=	**95.00 MT/day**

3. TOTAL SOLID WASTES GENERATED IN THE PUBLIC AREAS OF HARDWAR INCLUDING COMMERCIAL AND INSTITUTIONAL AREAS

SW generated outside households by permanent	:	2,35,074 X 100 gm
population @ 20% of generation rate	=	23.5074 MT
i.e. 100 gm/capita/day		
SW generated by floating population	:	1,00,000 X 300 gm
		= 30.00 MT/day

Total SW generated in public areas of Hardwar: 53.5074 MT/day

(say) = 54.00 MT/day

6.5 AN IMPLEMENTATION PLAN FOR ONSITE HANDLING STORAGE AND PROCESSING OF SOLID WASTES IN HARDWAR

The first step of the Solid Wastes Management process has to be taken at the very source of the solid waste i.e. at the generation points of the Municipal Solid Wastes (MSW) as explained in Chapter 2. It is essential to have a consistent and integrated practice for each type of MSW namely:

a) Residential

b) Commercial

c) Institutional

d) Construction and Demolition Debris

e) Hazardous wastes (other than industrial)

f) Bulky Wastes

We shall deal with the handling and storage methods for each type of MSW in Hardwar in the following section.

6.5.1 STORAGE OF RESIDENTIAL WASTES IN HARDWAR

The handling, processing and storage methods of residential wastes will vary depending on the economic groups of the population. The quantity of waste generated and its characteristics have been found to vary according to the economic status of the generators. The higher the income, greater is the quantity of waste generated and the waste composition is also more diverse than for the wastes generated by the lower income groups as discussed in Section 3.2 of Chapter 3.

In the case of Hardwar too, the same criteria is applicable and so the storage methods can be conveniently divided based on the same criteria.

a) Storage of Wastes in MIG and HIG Residences/Households

i) Two bins storage system will be practiced.

ii) Vegetative/putrescible/biodegradable wastes which are primarily food wastes and called Wet wastes shall be stored in a coloured plastic/metallic bin of minimum 10 liters capacity. This bin **MUST HAVE** a lid and a handle for easy carriage, without making any contact with the waste. The bins will be procured and maintained by the households.

iii) The dry wastes shall be stored in a white plastic/metallic container of minimum 5 liters, but preferably 10 liters, capacity. This container should preferably have a lid, however a carrying handle is mandatory. The dry wastes shall consists of paper, plastics, glass, metals, cardboard, leather, textiles, wood and all other items of now food items. However the empty packaging materials for tinned, canned and polypacked food materials shall be considered as dry wastes.

iv) The garden trimmings and yard wastes consisting of tree branches, dead leaves and dust will be home composted/burnt or disposed along with food wastes but under no circumstances should it be dumped or heaped outside the residential premises.

v) Items containing any harmful chemicals, like dry cells, dead acid batteries, medicines, insecticides, pesticides, mosquito repellants, phenolic compounds, paints, varnishes, waste oils and lubricants will be stored separately by the generator and handed over to the collector after informing him about the contents.

b) Storage of Wastes in LIG Residences/Households

i) The LIG households shall have one bin storage of wastes, primarily for vegetative/putrescible wastes of food origin. The bin should be made of plastic/metal, coloured and of 10 liters capacity minimum and it must have a lid and a handle. The bins will be procured by the households and maintained by them.

ii) For the dry wastes of non-food origin, the community storage will be practiced. The LIG residential areas will be provided with appropriately located carrier bins, which are convenient for the households and also easy to collect. The carrier bins shall be provided at a scale of 01 bin for every 2000 households assuming a generation rate of 0.5 kg per household per day at the rate of 100 gm/capita/day for an average household of 5 persons.

iii) In the areas characterized by narrow lanes and absence of access roads, where there are no suitable sites for placing carrier bins, 100 liters capacity metallic drum type bins with lids and handles will be provided strictly for disposal of dry wastes of non-food origin. These bins shall be provided at a scale of 01 bin for every 50 households assuming the same generation rate as mentioned in the previous paragraph.

6.5.2 COMMERCIAL AND INSTITUTIONAL WASTES

Hardwar being a services based town, the high intensity of trading and retailing activities lead to the generation of a large quantity of solid wastes. The predominantly commercial activities are related to the high level of trading activities and services for the tourists. Thus there is a large quantity of solid wastes generated in the commercial areas that have to taken into consideration and planned for in an integrated manner from storage to disposal.

a) <u>Storage of Wastes in Commercial Premises Generating only Dry wastes</u>

i) The individual proprietors will be responsible for storing their wastes within their premises. They will store the wastes in a white plastic/metallic container of minimum 10 liters capacity and having a lid and handle. The dust from floor sweeping will also be stored in the same container/

ii) Offices and shops, which generate larger quantities of dry wastes, will have appropriate sizes of white containers but not exceeding 100 liters. In case required multiple white containers of 100 liters capacity will be used.

iii) The proprietor is responsible for procuring and maintaining all such containers.

b) <u>Storage of Wastes in Commercial Premises Generating Both Wet Wastes and Dry Wastes</u>

i) Two bins storage system will be practiced.

ii) Depending on the quantity of wet waste being generated the proprietor shall arrange for the required numbers of yellow coloured plastic/metallic containers will handles and lid and having capacity of 10 liters to 100 liters. This applies particularly to restaurants, hotels, cinema halls, Dharamshalas, sweet shops, fast food stalls, office canteens etc.

iii) The dry wastes will be stored in separate white plastic/metallic container of capacity that is adequate and commensurate with the quantity of waste being generated.

c) <u>Storage of Wastes In Schools, Colleges and Other Educational Institutions</u>

i) All educational institutions would store within their premises all dry wastes generated by them and the wastes of area sweeping in white plastic/metallic containers, with lid and handles. Depending on the total number of people involved in generation of the wastes, the capacity of the bin shall vary between 25 to 100 liters.

ii) Educational Institutions having canteen and kitchens or resident scholars will have separate yellow coloured plastic metallic containers, with lid and handles, for storing the wet wastes. The capacity will vary from 25 to 100 liters depending on the requirement of the institution. In case wastes generated requires more storage space, multiple containers of up to 100 liters capacity can be used.

d) Storage of Wastes in Ashrams

i) Two-bins storage system of wastes will be practiced even in Ashrams as explained for the commercial complexes like hotels/dharamshalas. The specification and capacities of containers will also be the same.

ii) It will be the responsibility of the Ashram management to provide adequate and proper storage of the wastes.

e) Storage of Wastes In Temple Premises

i) The management committees of temples will be responsible for placing adequate numbers of 100 liters plastic/metallic containers having pedal operated lid and proper handles, within the area adjoining temples.

ii) Yellow coloured containers with proper marking /instructions for throwing in only wet wastes will be placed at convenient sites for use by the visitors to the temple.

iii) Separate white coloured containers for dry wastes will be co-located with the yellow coloured containers for wet wastes. The white containers will have proper marking/instruction that only dry, non-food wastes should be thrown into the white containers.

iv) Wastes from area sweeping will also be stored along with dry wastes.

f) Storage of Wastes In Hospitals, Nursing Homes, Dispensaries, Primary Health Centres

i) All types of biomedical wastes will be stored in properly lidded containers as per the colour coding prescribed in the Bio-medical Waste (Management and Handling) Rules, 1998. The management/owner of the concerned medical facility will be responsible to maintain adequate numbers and capacities of such containers. However, the capacity of each container should not exceed 100 liters.

ii) The medical institutions shall also have separate coloured containers for all other wastes being generated (other than bio-medical) as per the Bio-Medical Waste (Management and Handling) Rules, 1998. The numbers and capacity will vary according to the requirement.

iii) The medical institutions will have white and yellow coloured containers for storing all non-medical origin dry and wet wastes respectively for such wastes being generated in their premises.

6.5.3 STORAGE OF WASTES IN PUBLIC PLACES

a) Storage of wastes in Public Places like market areas, parks and playgrounds, bathing ghats, railway station, bus-terminus etc.

i) Here too two-bins storage system will be provided.

ii) The yellow coloured and the white containers of 100 liters capacity will be co-located at appropriate sites in these premises. Suitable instructions/markings will be given on the bins, indicating that yellow coloured containers are to be used for biodegradable wastes of food origin and white containers are to be used for dry wastes.

iii) The area sweepings will be stored along with dry wastes.

iv) These bins will be placed on roadsides on Upper Road, between Motichur and Har ki Pairi, Moti bazar, along built up ghats, around temple premises, bus terminus, railway station and other public places.

v) These bins will be placed at every 100 metres in areas mentioned above. These will be provided locking arrangements with electric/telephone poles to prevent theft.

v) At locations like bus-terminus and railway station if the site conditions permit and where the total generation is high due to large transient population the large capacity (4.5 cubic meters) carrier bins should be placed.

vi) Yard wastes like leaves, garden trimmings, twigs and tree branches shall be either burnt at site or kept at site till they are handed over separately to collection vehicles by concerned SK.

b) <u>Storage of wastes by Hawkers, Pedlars and Mobile Vendors with pushcarts</u>

This category of generators would be required to carry a plastic/metallic container of minimum 25 liters capacity, which shall be used by them for storing their wastes while they are moving around. These people will empty their waste containers in the nearest available communal storage system for biodegradable wastes (yellow coloured) as the non-biodegradable portion in their wastes would be negligible. In case of vendors selling non-food products, they will discharge the wastes from their containers into a communal storage system for non-biodegradable wastes (white coloured).

6.5.4 CALCULATION OF ONSITE STORAGE REQUIREMENTS FOR SOLID WASTES GENERATED IN PUBLIC PLACES OF HARDWAR

Solid waste generated by the permanent population outside residences (Refer Section 6.4)	:	23.5074 MT = 24 MT (say)
Solid wastes generated per day by the floating population	:	30.0 MT
Total SW generated outside households	:	54.0 MT
Storage capacity required for 54 MT SW @ 350kg/m^3 density	:	154.28 m^3 = 155 m^3 (say) = 1,55,000 litres
Total number of 100 litres bins required	:	1550 Nos.
Density of twin bins @ every 100 m placement	:	8 per hectare
Area covered by bins @ 8 bins/ha	:	193.75 ha 193 ha (say)

6.5.5 STORAGE OF CONSTRUCTION AND DEMOLITION DEBRIS

The storage of construction and demolition debris shall be arranged within the premises of the property where such actually is carried out. In case, there is no storage space within the premises of the property then the proprietor will arrange for immediate transfer of such wastes to pre-designated disposal site earmarked by the municipality. Under no circumstances shall the construction and demolition debris be dumped on roadsides, vacant plots open-spaces or in areas earmarked for disposal of other solid wastes. However, the municipality may permit/direct the generation for dumping the construction and demolition wastes in low-lying areas that are required to be raised in level for further development. In such a case, it will save part or complete expenditure by the municipality for filling operation.

6.5.6 STORAGE OF BULKY WASTES IN HARDWAR

The bulky items like furniture, refrigerators, television, automobiles are very rarely generated as solid wastes in Indian cities, including Hardwar but yet there are always few such things to be found lying on road-sides, outside garages and shops for long periods. This is mostly because the item has lost its resale value even as scrap and the owner is unable to get desired price by its sale. People will be required to either store such items/wastes within their own property limits or deposit such items in pre-designated yards, of the municipalities/private operations for further disposal. No storing of such bulky items shall be permitted on public land, roadsides etc.

6.6 PROPOSED COMMUNAL STORAGE SYSTEM FOR HARDWAR

The report of the Committee constituted by the Honourable Supreme Court of India, on the Solid Waste Management in Indian cities has specified in its recommendations that there is a need to bring about a conceptual change in the communal storage system in Indian cities. The open dumps and concrete/masonry bins (dalaos or depots) must be abolished and replaced with mobile closed body containers. The report also recommends the synchronization of the transportation system with the waste storage facilities. The Municipal Solid Waste (Management and Handling) Rules, 2000, has now mandated many of such recommendations as already discussed in Section 3.8 of this report.

It is in the light of these pertinent and valid recommendations and the mandatory regulations that the proposed communal storage system in Hardwar recognises the need for the primary and secondary collection system in Hardwar. This is necessitated by the fact, that many areas in the city are not accessible by the collection vehicles such as tipper trucks, tractor-trailers, dumper placers, and so the collection of solid wastes from generation point/source has to be based on small vehicles such as handcarts, pedal tricycles and motor tricycles.

The collection system involves the collection of solid waste, stored at generation points, by the non-motorised/small collection vehicles (primary collection). When fully loaded to capacity, the primary collection vehicle is emptied directly into a waiting large motor vehicle, which is employed solely for the high-speed transport of full load.

Thus not only is an onsite storage container required at the point of generation, but also a larger storage container is required where the entire community's wastes can be collected by the SKs for transportation to processing/disposal sites. The large open dumps, dalaos, and carrier bins are all arrangements for communal storage of solid wastes in Hardwar as explained in Chapter 5.

However, in the opinion of the author the stationary units of communal storage like open dumps and dalaos are not a recommendable option due to the following reasons:

a) Wastes are strewn about the site by the scavenging activities of animals and rag pickers.

b) The residents, offended by the site, do not walk into the unit or to its opening to discharge their wastes and instead throw the wastes around the dalao/open dump thus spreading the wastes further.

c) Breeding of flies, vermin, pets and other disease vector is facilitated by these open communal storage arrangements.

d) The SKs removing the wastes manually come in contact with the wastes.

Portable units for communal storage such as carrier bins trailers and steel drums are particularly useful for cities such as Hardwar, which are characterized by densely populated city core and inaccessible areas. The advantages of a portable unit are:

a) It allows most efficient use of transport vehicles, viz a viz collection vehicles, by shuttling back and forth to the disposal site with filled containers.

b) When properly planned for capacity and siting, littering of wastes around the bins can be avoided.

c) Prevents intervention by scavengers and animals.

d) If covered, these covered portable storage units retard breeding of disease vectors.

e) No manual handling of wastes is required, thus poses least health hazard to the SKs.

In Hardwar carrier bins are being used, though to a very small extent, for communal storage of solid wastes as explained in Chapter 5. The author proposes another innovative system for communal storage of wastes that is available with the P.H. and S. Department of Hardwar and can be effectively used as communal storage system for segregated wastes with a little modification.

The tractor-trailers that are used for primary collection in Hardwar can also be used for secondary collection and communal storage of wastes. These have to be covered, as a pre-requisite for usage as communal storage systems. Just as the carrier bins are located at various points, these trailers also can be sited at suitable points to enable collection. The trailer will also be divided into two separate containers for storing dry and wet wastes separately. Figure 6-5 shows the modified tractor-trailer for collection of solid wastes, where the trailer detached from the tractor, will be located at a site and used for communal storage of the waste. The tractor will be used to transport the trailer to processing/treatment sites only. Thus a single tractor can service a number of such trailers giving better vehicle efficiency than the coupled tractor-trailer arrangement.

The basic premise on which the storage system is devised is the issue of optimising recovery and recycling of energy and materials from the wastes. The source segregation of wastes proposed, is aimed directly at that. Also in an effort to integrate the entire process of SWM from generation to disposal, the issue of source segregation has been considered of paramount important. Not only will it ease recovery and recycling of energy and materials but also greatly facilitate the processing/treatment of wastes namely composting and /or incineration if any. In addition the source segregation of wastes will also reduce the pollution load at the disposal end viz a viz unsegregated wastes. The segregation of hazardous/toxic materials at source from the biodegradable waste would also make component identification easier and thus greatly influence the disposal method. This would greatly reduce the threat potential /hazard of the wastes at all stages of handling considerably.

The single most important factor, which influences storage requirements of solid wastes at the generation point and at the communal storage site, is the collection frequency. In fact the collection frequency forms the basis for the provision of storage space for solid wastes. It is a widely accepted fact that due to the climatic conditions prevalent in India and the high putrescible content of Indian wastes, it is essential to have a high frequency of collection with even daily or six days a week collection being considered appropriate. However, the implications of the collection frequency are more significant than is often realised.

In the case of daily collection, contrary to expectations and belief the capital expenditure on vehicles and equipment is the least as compared with any other frequency of collection, simply because the wastes being collected are the least-that generated in one day. For even a six days a week collection frequency the requirement of storage space, collection vehicles, handling tools and equipment, plant and machinery for treatment of waste and finally the collection staff will be doubled, just because of the need to handle double the quantity of wastes, only on one day of the week. In working out the proposals for SWM in Hardwar both options have been considered and since the six days a week collection entails greater expenditure (Refer Sections 6.5.2.1 and 6.5.2.2) it is not recommended and a seven days a week collection system is proposed for Hardwar.

6.6.1 CALCULATIONS FOR COMMUNAL STORAGE REQUIREMENTS OF HARDWAR

To simplify the working out of various details pertaining to the communal storage requirements for Hardwar certain assumptions have been made. These are given below:

(a) The total communal storage requirement for Hardwar caters for only the permanent population and the daily floating population of 1,00,000. It does not cater for the excess populations arriving in Hardwar for special religious occasions. That will be dealt with separately.

(b) Collection schedule once fixed will not be upset due to any reasons of human or mechanical failure so as not to increase the storage requirement.

(c) The total communal storage requirement for Hardwar will be met by providing Carrier Bins for 60% of the total solid wastes generated and Modified Trailers for the balance 40%. This distribution is made on the basis of the parking requirement of the Carrier bins and the Tractor-trailers. The tractor-trailers require a greater parking area than the carrier bins and therefore its usage is restricted to wider roads and areas.

6.6.1.1 FOR SEVEN DAYS A WEEK COLLECTION

As mentioned above, in the case of seven days a week collection, the daily communal storage requirement is equal to the total amount of solid wastes generated per day. Therefore for a seven days a week collection in Hardwar, storage space has to be provided for a maximum of 148 Metric Tonnes (MT) of solid waste.

Maximum Wastes To Be Stored :148.0 Metric Tonnes

A. Number of Carrier Bins (CBs) Required

It is proposed to provide CBs for storage of 60% of the total SW generated in Hardwar.

Quantity of SW for which CBs are	:	60% of 148 MT
required	=	88.8 MT
	=	89.0 MT (say)
Number of CBs required @ 1.5 MT/CB	:	59.33
	=	**60 Nos. (say)**

B. Number of Modified Trailers Required

It is proposed to provide Modified Trailers for storage of 40% of the total SW generated in Hardwar.

Quantity of SW for which Modified Trailers are required	:	40% of 148 MT
	=	59.2 MT
	=	60.0 MT (say)
Number of Modified Trailers required @ 2 MT/Modified Trailer	:	**30 Nos. (say)**

6.6.1.2 FOR SIX DAYS A WEEK COLLECTION

It has already been discussed above that in case collection is carried out six days a week then the communal storage required is double that for seven days a week collection, just to cater for the wastes of the non-collection day. Thus for six days a week collection frequency communal storage space has to be provided for 296 Metric tonnes (2 X 148 MT) of SW.

A. Number of Carrier Bins (CBs) Required

It is proposed to provide CBs for storage of 60% of the total SW generated in Hardwar.

Quantity of SW for which CBs are required	:	60% of 296 MT
		= 177.6 MT
		= 178.0 MT (say)
Number of CBs required @ 1.5 MT/CB	:	118.7 = **119 NOS. (SAY)**

B. Number of Modified Trailers Required

It is proposed to provide Modified Trailers for storage of 40% of the total SW generated in Hardwar.

Quantity of SW for which Modified Trailers are required	:	40% of 296 MT
	=	118.4 MT
		= 119 MT (say)
Number of Modified Trailers required @ 2 MT/Modified Trailer	:	59.5 Nos. (say)
		= **60 Nos. (say)**

6.6.2 EXPENDITURE ON COMMUNAL STORAGE OF SOLID WASTES IN HARDWAR

6.6.2.1 FOR SEVEN DAYS A WEEK COLLECTION

A. Number Of Carrier Bins (CBs) Required	:	60 Units
Cost Of CBs @ Rs. 40,000/-	:	Rs. 24.00 Lakhs
Cost Per Household (47,015 Total)	:	Rs. 51.05
B. Number Of Modified Trailers Required	:	30 Units

Cost Of Modified Trailers @ Rs. 60,000/-	:	Rs. 18.00 Lakhs
Cost Per Household (47,015 Total)	:	Rs. 38.30
Therefore total expenditure on Communal storage For seven days a week collection	:	**Rs. 42.00 Lakhs**
Expenditure per Household	:	Rs. 89.35

6.6.2.2 FOR SIX DAYS A WEEK COLLECTION

A. Number Of Carrier Bins (CBs)Required	:	119 Units
Cost Of CBs @ Rs. 40,000/-	:	Rs. 47.60 Lakhs
Cost Per Household (47,015 Total)	:	Rs. 101.25
B. Number Of Modified Trailers Required	:	60 Units
Cost Of Modified Trailers @ Rs. 60,000/-	:	Rs. 36.00 Lakhs
Cost Per Household (47,015 Total)	:	Rs. 76.60
Therefore total expenditure on Communal storage For six days a week collection	:	**Rs. 83.60 Lakhs**
Expenditure per Household	:	Rs. 177.85

6.7 A COMPREHENSIVE COLLECTION PLAN FOR SOLID WASTES IN HARDWAR

In an integrated solid wastes management plan all the functional elements are evaluated for use, and all of the interfaces and connection between elements are matched for effectiveness. Therefore in developing a management plan for solid wastes in Hardwar the storage systems for wastes arising out of the various sources have been developed based on a comprehensive collection plan so as to optimise the efficiency of entire SWM operations. It is in this context that the concept of interfaces and connections, between different functional elements, has been viewed.

Even the best planned and executed storage system for solid wastes would serve no purpose, unless it is interfaced with an equally well planned and executed collection plan.

In fact, ***in the realm of solid wastes management the most perceptible consequences are mostly the manifestation of collection process.*** A garbage free city is one which witnesses efficient collection and vice-versa. So ***from the user satisfaction point of view, the functional element of collection is the single most important process.***

The proposals of the collection plan for solid wastes in Hardwar are divided broadly into two parts:

1. The Types of Collection Services to be Provided.
2. The Types of Collection Systems, Equipment and Personnel Requirements.

6.7.1 TYPES OF COLLECTION SERVICES TO BE PROVIDED

Under this section the procedures and systems for Collection of wastes from the different types of generators is proposed. It is at this stage that the service is directly perceived by the users, and so it has to be planned, organised and executed efficiently.

6.7.2 COLLECTION OF SOLID WASTES FROM RESIDENTIAL AREAS ACCESSIBLE BY COLLECTION VEHICLES

In the residential areas which are accessible by collection vehicles, the collection crew accompanying the collection vehicle, motor tricycle or handcart as the case may be, will go from door to door, ring the bell or call out for the houseowner. The houseowner will be responsible for handing over the storage bins of both dry and wet wastes to the SK at the entrance when called to do so. The SK will take the storage bins and empty them into the respective containers/compartments in the collection vehicle and return the bins to the entrance of the household. Thus at a time two to four SKs can simultaneously collect from as many number of households.

6.7.3 COLLECTION OF SOLID WASTES FROM RESIDENTIAL AREAS NOT ACCESSIBLE BY LARGE COLLECTION VEHICLES

In the residential areas which are not accessible by this large collection vehicles like tipper trucks and tractor trailers, the door to door collection will be carried out using pedal tricycles, handcarts and motor-tricycles, depending on the accessibility of the houses.

Here again the SKs will be required to go from door-to-door and call/ring at the door of each house. The resident shall be responsible for handing over the two bins of wet and dry wastes to the SK. The SK will empty the bins into respective containers, of dry and wet wastes, brought by him and return the bin to the resident.

After the containers of the SK's collection equipment, be it handcarts, pedal tricycle or motor-tricycle, is filled up, he will carry the containers to the pre-designated communal storage system located in the area, to receive the wastes from that area.

6.7.4 COLLECTION OF RESIDENTIAL WASTES FROM LIG AREA

As explained earlier, the LIG households would be required to store only biodegradable wastes in coloured containers. The SKs detailed for an area will go for door-to-door collection from his area of responsibility. The procedure will be the same as for collection from househoOlds in other residential area.

For the dry wastes for the LIG residential areas, if the carrier bins are being placed, then these will be collected by the dumper placers for further disposal. If the LIG areas are not accessible by the tractor driven dumper placers or there is no place for siting the carrier bins, then the 100 litres bins will be picked up by SKs using handcarts, pedal tricycle or motor-tricycle depending on accessibility. Thereafter these bins will be emptied into either a carrier bin/trailer at the communal storage points and then returned to their respective locations by the SKs.

6.7.5 COLLECTION OF SOLID WASTES FROM COMMERCIAL AND INSTITUTIONAL PREMISES

Door-to-door collection of solid wastes will be practised even for the commercial and institutional establishments whose solid wastes storage systems have already been described. In the case of commercial/institutional premises which are located on such roads that they can be accessed by the collection vehicles like tipper trucks, tractor trailers, the storage bins from these premises will be picked up from the entrance of the premises by the SKs accompanying the collection vehicles, and returned to its locations by them after emptying the contents into the containers in collection vehicles.

6.7.6 COLLECTION OF SOLID WASTES FROM PUBLIC AREAS

The SKs detailed for the public areas such as markets, bus-terminus, railway stations, temple premises, ghats etc will sweep the area of responsibility and directly collect the waste in handcarts containing bins for bio-degradable and now biodegradable wastes. In addition they will empty the 100 litres storage bins which are placed in their area of responsibility into their bins and carry collected wastes to a pre designated communal storage site and empty their bins into the carrier bin/trailer. Solid wastes will also be collected from the 100 litres bins placed in the public areas by the Motor tricycles wherever the bins are approachable by the vehicles.

Similarly the road sweepings will also be collected in containerised handcarts by the SKs responsible for area sweeping.

6.7.7 COLLECTION OF HAZARDOUS SOLID WASTES IN HARDWAR

The hazardous wastes shall be collected from all identified sources, by a separate collection vehicle. Separate vehicles with appropriate facilities will collect wastes from similar sources such as sources generating bio-medical wastes, sources generating chemical and toxic wastes.

The hazardous wastes identified for incineration such as bio-medical wastes, will be transported to the incinerator site and similarly other hazardous wastes will be transported to respective processing/disposal sites.

The collection vehicles for hazardous wastes shall be covered vehicles of appropriate capacity and they will have the danger insignia and marking indicating that these are carrying hazardous wastes.

The SKs involved in collection processing and disposal of hazardous wastes shall be provided protective clothings such as gloves, rubber shoes, face-masks and rubberised overalls.

6.7.8 COLLECTION OF SILT AND SOLIDS REMOVED FROM SEWERS IN HARDWAR

The silt and solids removed from sewers using the sewer cleaning machines will be collected directly into open trailers co-located with the machines. At the end of the cleaning operations the trailers will be towed away by tractors, which will report to the site at the given time of closure of sewer cleaning. The sewer cleaning and desilting operations will be carried out at nights only, to prevent any interference with the day time traffic.

6.7.9 COLLECTION OF CONSTRUCTION AND DEMOLITION DEBRIS

The collection of construction and demolition debris will be arranged by the P.H. and S. department of NPP, Hardwar on receiving a request from the owner and payment of a fixed fee for each trip made for disposal of such waste.

6.8 TYPES OF COLLECTION SYSTEM, EQUIPMENT AND PERSONNEL REQUIREMENTS

Various types of collection systems and equipment are used in the developed countries to achieve high efficiency and standards of solid wastes collection as discussed in Chapter 2, however, most of these system employ sophisticated technology and in spite of their high costs, are cost effective for developed countries with high labour costs. But in India, the labour intensive techniques and systems are more viable due to availability of cheap labour. So while devising the collection system for Hardwar the optimal use of mechanical systems have been incorporated into a framework of labour intensive collection system.

A Modified Hauled Container System (HCS) is proposed for the city of Hardwar as against the Stationary Container system due to the inherent drawbacks of the Stationary Container units explained earlier. In the Hauled Container System, the containers used for the storage of wastes are hauled to the disposal site, emptied and returned to either their original location or some other location.

In the case of Hardwar it is proposed to combine the short-range transfer operation with the Hauled Container system, thus combining the advantages of both to give an optimal result.

The short-range transfer is a system that divides the refuse collection into two phases of primary and secondary collection. Primary collection from, door-to-door is performed by small/non-motorized vehicles and once these are full, the vehicles are brought to the site where the larger container is located and emptied into it. The larger container is hauled by a complimentary vehicle used for speedy transportation of full loads to processing disposal sites.

There are two modes of the hauled container systems:

a) Conventional mode - in this mode the containers are hauled one by one from their location to the processing/disposal site, emptied and returned to their respective location. Figure 6-1 gives the schematic diagram of the conventional mode.

b) Exchange container mode - in this mode the containers are replaced by an empty container picked up from previous site and already emptied. This system reduces travelling distance and time in the full circuit of operation. Figure 6-2 gives the schematic diagram of the exchange container mode.

The work performed by a refuse collection vehicle can be divided into two parts:

a) the period while it is stationary during loading represents lost time for the prime mover

b) the period which is spent travelling at normal road speed with a full load represents efficient use of the prime mover.

Thus for maximum productivity in terms of ton/km transported, loading time must be reduced to a minimum. If the vehicle can be split into the two parts, the prime mover and the body, loading time can even be eliminated by providing an extra body, which can be loaded while the first one is being taken to disposal. This analysis can also be applied to any refuse collection vehicle/equipment including the carrier bins tractor and trailer etc.

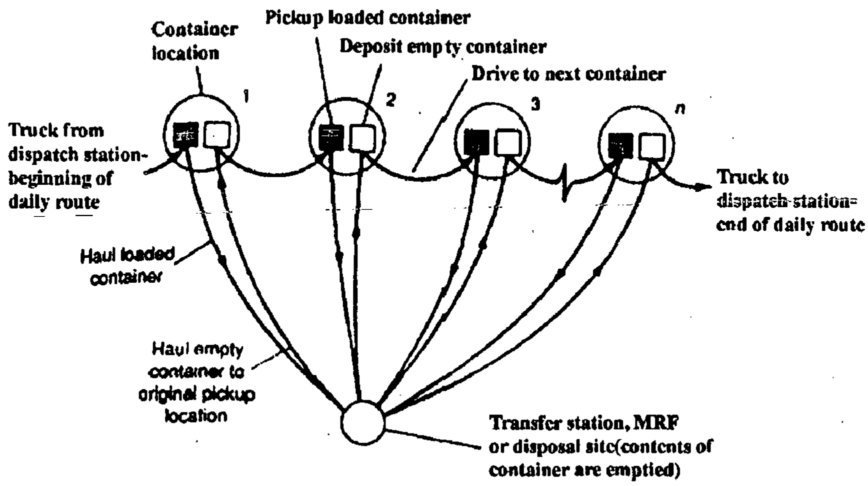


FIGURE 6-1: CONVENTIONAL MODE OF HAULED CONTAINER SYSTEM
(Source: Tchobanoglous, et el, 1993)

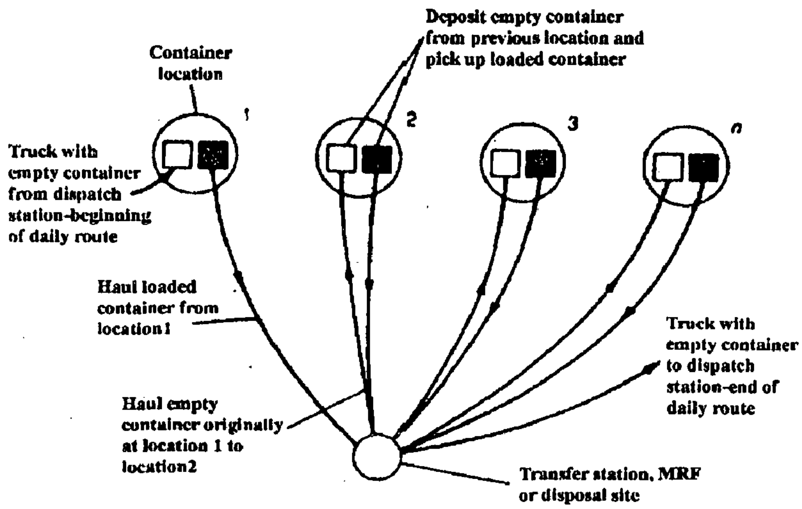


FIGURE 6-2: EXCHANGE CONTAINER MODE OF HAULED CONTAINER SYSTEM
(Source: Tchobanoglous, et el, 1993)

6.8.1 COLLECTION TIMINGS AND DETAILS OF VEHICLES AND EQUIPMENT FOR COLLECTION OF SOLID WASTES IN HARDWAR

The details of the collection vehicles and equipment have been worked based on certain logical assumptions listed below, however the factual ground data will have to be obtained to implement the SWM plan. The operating principles, will however remain the same with only the figures modified as per the ground realities of accessibility/approachability, residential density, circulation patterns and traffic conditions.

(a) In the residential areas 60% of the households are accessible only by handcarts for SW collection and 40% households are approachable by motor-tricycles.

(b) Households on first floors and above of any building are responsible fort placing their bins at the entrance of the building on the ground floor.

(c) 40% of commercial and institutional premises in Hardwar are approachable only by handcarts for SW collection and 60% are approachable by motor-tricycles.

(d) Due to the mixed landuse pattern and the concentration of commercial and institutional premises in specific areas of the city handcarts make an average of two trips per day and motor-tricycles also make an average of two trips per day.

(e) The average density of the solid wastes in Hardwar is taken as 350 kg/m^3, by taking the lower value of the average Indian city solid waste (Refer Table 2-1).

(f) The working hours per day shall be 08 hours, with one hour lunch break included, thus giving an effective working time of 07 hours (420 minutes).

6.8.1.1 PRIMARY COLLECTION FROM RESIDENTIAL AREAS

A. <u>COLLECTION BY HANDCARTS</u>

Handcart capacity 6X100 litres bins	:	600 litres
One handcart load @ SW density	:	210 kg

350 kg/m^3

Generation of wastes per Household (HH) @ 5persons/HH generating @ 400 gm/capita /day	:	2.0 kg
Number of HHs served per handcart load	:	105

However, we restrict per trip collection to only 80 households, to keep the handcart load manageable and also to keep the collection time per trip such that two trips can be made.

Door-to-door collection time @ 02 minutes/HH	:	160 minutes
Travel time to secondary collection and back 500mX2 @ 3 kmph	:	20 minutes
Unloading time at secondary collection point	:	15 minutes
Delay allowance for complete trip	:	15 minutes
Total time taken for complete trip	:	210 minutes
Total No. of HHs served per trip	:	80
Total SW collected per trip	:	160 kg
Number of trips per day	:	02
Number of HHs served/handcart/day	:	160
Total SW collected/handcart/day	:	320 kg

Total number of HHs to be serviced by handcarts @ 60% of total HHs (47,015)	:	28209
Total number of handcarts required for collection from residential areas	***:***	***177 Nos.***
Total No. of Safai Karmacharis required @ 01 SK per handcart	***:***	***177 Nos.***

B. COLLECTION BY MOTOR TRICYCLES

Capacity of Motor Tricycle	:	02 m^3
Load per vehicle(@ SW density 350kg/m^3)	:	700 kg
Generation of wastes per household	:	2.0 kg

(HH) @ 05 persons/HH generating
@ 400 gm/capita /day

Number of HHs from which wastes can be collected in one trip	:	350
Door-to-door collection time @ 04 crewX30dwellings/man/hour	:	175 minutes
Travel time to secondary collection and back 01KmX2 @ 15 kmph	:	08 minutes
Unloading time at secondary collection point	:	15 minutes
Delay allowance for complete trip	:	12 minutes
Total time taken for complete trip	:	210 minutes
Total No. of HHs served per trip	:	350
Total SW collected per trip	:	700 kg
Number of trips per day	:	02
Number of HHs served/vehicle/day	:	700
Total SW collected/vehicle/day	:	1400 kg

Total number of HHs to be serviced by Motor tricycles @ 40% of total HHs (47,015)	:	18,806
Total mumber of Motor Tricycles required for collection from residential areas	***:***	***27 Nos.***
Total No. of Safai Karmacharis required @ 04 SK per Motor Tricycles	***:***	***108 Nos.***
Total No. of Drivers required @ 01 Driver per Motor Tricycles	***:***	***27 Nos.***

6.8.1.2 PRIMARY COLLECTION FROM PUBLIC PLACES

The onsite storage of the solid wastes in the public areas has already been discussed in Section 6.4.2 and 6.4.3 and the collection system to be followed has been elaborated in Section 6.6.6. It is pertinent to mention here that 100 litres bins shall be used for the onsite storage of solid wastes in the public areas. Handcarts with 4X100 litre bins and motor tricycles will be used for primary collection of the wastes from the storage bins.

A. COLLECTION BY HANDCARTS

Handcart capacity 04X100 litres bins	:	400 litres
One handcart load @ SW density 350kg/m^3	:	140 kg
Number of bins emptied into handcart	:	04
Collection time @ 02 minutes/bin	:	08 minutes
Travel time between bins 100m @ 03 kmph	:	02 minutes
Travel time to the secondary collection Point and back, 1kmX2 @ 3 kmph	:	40 minutes
Unloading time	:	10 minutes
Delay allowance	:	10 minutes
Total collection time per handcart load	:	70 minutes
Total No. of handcart loads collected per day in 07 hours working time	:	06 Nos.
Bins emptied/handcart/day	:	24 Nos.
Solid waste collected/handcart/day	:	840 kg
Total No. of bins to be emptied by handcarts @ 40% of total No. of bins (1550)	:	620 nos.
Total No. of handcarts required for primary Collection from public areas	:	***26 Nos.***
Total No. of Safai Karmachari (SK) required @ 02 SK/handcart	:	***52 Nos.***

B. COLLECTION BY MOTOR TRICYCLE

Capacity of Motor Tricycle	:	02 m^3
Load per vehicle(@ SW density 350kg/m^3)	:	700 kg
Number of bins emptied into Motor Tricycle in one trip	:	20
Collection time @ 02 minutes/bin/02 SKs	:	40 minutes

Travel time between bins @ 02 per 100m So 1000m @ 10 kmph	:	06 minutes
Travel time to the secondary collection point and back, 02kmX2 @ 15 kmph	:	16 minutes
Unloading time	:	15 minutes
Delay allowance	:	10 minutes
Total collection time per handcart load	:	87 minutes
Total No. of vehicle loads collected per day in 07 hours working time	:	04 Nos.
No. of Bins emptied/vehicle/day	:	80 Nos.
Solid waste collected/vehicle/day	:	2800 kg

Total No. of bins to be emptied by Motor Tricycle @ 60% of total No. of bins (1550)	:	930 Nos.
Total No. of Motor Tricycles required for primary collection from public areas	:	***12 Nos.***
Total No. of Safai Karmachari (SK) required @ 02 SKs/Motor Tricycle	:	***24 Nos.***
Total No. of Drivers required @ 01/ vehicle	:	***12 Nos.***

6.8.1.3 SECONDARY COLLECTION FROM COMMUNAL STORAGE

As discussed in Section 6.5 it is proposed to use Modified Trailers and Carrier Bins for communal storage as these are Hauled Container systems. The various details of collection of these communal storage devices are worked out in this section.

To simplify the working out of the secondary collection vehicles and equipment certain baseline assumptions as listed below, have been made.

(a) Working time per day is 07 hours i.e. 420 minutes.

(b) Average turnaround of Disposal site from collection point is 20 Km considering the nearest and the farthest loading points.

(c) Average speed of tractors with trailers/ Carrier Bins is 15 kmph and average speed of Tipper Trucks is 20 kmph.

(d) Trailers are loaded to a capacity 6 m^3 i.e. 02 Metric Tonnes (MT) and Carrier Bins are loaded to 4.5 m^3 i.e. 1.5 MT and Tipper Trucks are loaded to capacity 05 MT.

A. <u>COLLECTION DETAILS OF MODIFIED TRAILER COLLECTED BY TRACTORS</u>

Time for exchanging Trailers by the prime mover Tractor	:	05 minutes
Time for travelling turnaround distance 20km @ 15 kmph	:	80 minutes
Unloading of wastes at disposal site	:	15 minutes
Delay time	:	05 minutes
Total time for 01 complete trip	:	105 minutes
No. of trips in one day's work time	:	04 trips
Total No. of Trailers transported per tractor per day	:	04
Total SW collected per Tractor per day	:	08 MT
Total No. of Tractors required for secondary collection of 30 Nos. Modified trailers	:	**08 Nos**

B. <u>COLLECTION DETAILS OF CARRIER BINS COLLECTED BY TRACTORS</u>

Time for exchanging carrier Bins by Tractor Dumper Placer unit	:	05 minutes
Time for travelling turnaround distance 20km @ 15 kmph	:	80 minutes
Unloading of wastes at disposal site	:	15 minutes
Delay time	:	05 minutes
Total time for 01 complete trip	:	105 minutes
No. of trips in one day's work time	:	04 trips

Total No. of CBs transported per tractor per day	:	04
Total SW collected per Tractor Dumper Placer unit per day	:	06 MT
Total Number of Tractor Dumper Placers Required for Secondary collection of 60 Nos. CBs	**:**	**15 Nos.**

C. <u>COLLECTION DETAILS OF TIPPER TRUCKS</u>

Time for travelling turnaround distance 20km @ 20 kmph	:	60 minutes
Unloading of wastes by tipping at the disposal site	:	15 minutes
Delay time	:	09 minutes
Total time for 01 complete trip	:	84 minutes
No. of trips in one day's work time	:	05 trips
Total SW collected per Truck per day	:	25 MT
Total No. of Tipper Trucks required for secondary collection of SW in Hardwar	**:**	**06 Nos.**

However there are a few pertinent problems in the use of tipper trucks for secondary collection as given below:

(a) Tipper trucks can be used for collection of wastes only from open dumps and open storage devices and not from Modified Trailers and carrier bins. Thus they are incompatible for secondary collection from Modified Trailers and Carrier Bins.

(b) If tipper trucks are to be used for the collection of waste directly from the primary collection vehicles then the vehicles waiting time will be increased and thus collection efficiency will be low with the vehicle making only one or two trips per day. Therefore tipper trucks are incompatible with the primary collection vehicles.

(c) Tipper trucks cannot be used for communal storage as they require larger parking space and also due to large capacity they would be placed too far apart to be effective as a communal storage device.

Thus the application of the tipper trucks in the day to day collection process in Hardwar is ruled out. However, the tipper trucks can be very effectively used on the days of large pilgrim influx to Hardwar. These can be placed at the Mela Grounds and solid wastes collected by the handcarts from the mela grounds can be directly discharged into the trucks. Due to the very large quantity of waste generated by the large number of pilgrims the use of tipper trucks for secondary collection is justified.

6.8.1.4 DESILTING OF SEWERS BY SEWER CLEANING MACHINES

We have already discussed the need for cleaning of sewer lines in Hardwar due to the choking of sewer lines by solid wastes thrown by the population as well as the silt from the hills and mountains (Refer Sections 4.5.3 and 4.5.4). To be able to work out the requirements of sewer cleaning machines we shall make a few assumptions. These are given below.

(a) Sewer cleaning machines shall be provided for maximum silting during summer monsoon.

(b) The Sewer cleaning machines will be operated for 07 hours per day.

(c) As per an operator of the machine the collection rate of each unit of the sewer cleaning machine is about 500 kg/hour. In the absence of any authentic data we accept this as planning figure.

Maximum Summer Monsoon silt	:	70 MT/day
Cleaning Efficiency of each Unit	:	0.5 MT/hour
Silt removed per unit/day (in 07 Hours)	:	3.5 MT/day
No. of units of Sewer Cleaning Machines	:	20

required @ 0.5 MT/Machine/Hour and
working time of 07 hours/day

No. of Sewer Cleaning Machines required : 10 Nos.
@ 02 Units per Machine

No. of operators required : 20 Nos.
@ 01 Operator/Unit

6.8.1.5 REQUIREMENT OF SAFAI KARMACHARIS FOR ROAD SWEEPING

The length of the Blacktopped road in Hardwar city is 105.224 km (Refer Section 4.5.1). To keep these roads clean and free from any garbage regular sweeping of the roads is required. The standards for road length to be swept by each Safai Karmachari (SK) has been recommended by the Report of the Commission constituted by the Hon. Supreme Court of India from 750 to 500 running meters of the road depending on the density of the area, road width and local conditions prevailing.

Since the road width of most roads in Hardwar is within 20 metres, it is recommended that each SK be allotted a stretch of 1km for road sweeping and cleaning. These SKs would also be responsible for depositing all the dirt and trash littered on the road into the onsite storage bins/communal storage devices as applicable in their areas.

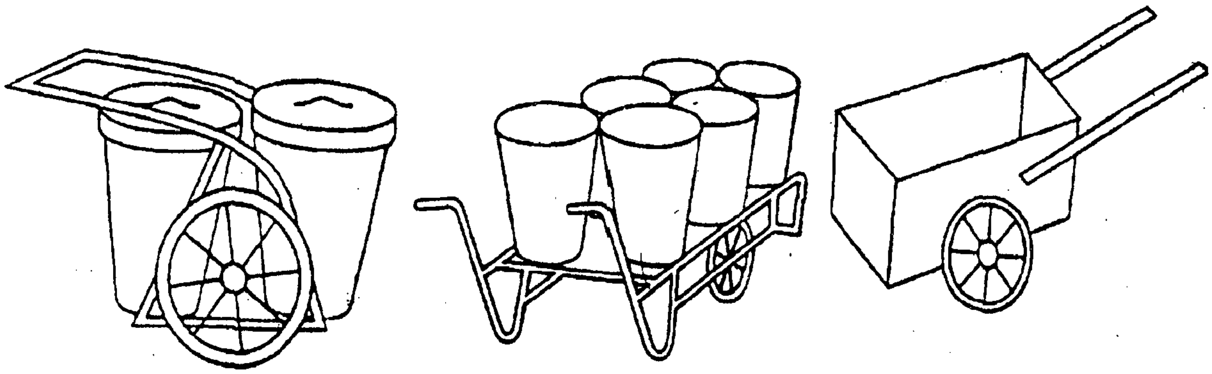
The total number of SKs required for road sweeping is 106.

6.8.2 COLLECTION VEHICLES AND EQUIPMENT PROPOSED FOR HARDWAR

On the basis of the above calculations and working details of various types of the primary and secondary collection vehicles we are able to visualise the requirements of the various vehicles and equipment for optimum performance of the SWM plan in Hardwar.

The various types of vehicles and equipment proposed for the collection of solid wastes in Hardwar are discussed in the subsequent sections. While proposing the vehicles and equipment it has been kept in mind that optimum use be made of the indigenous vehicles and equipment which is not only easily available in the Indian markets, but also that its maintenance can easily be done locally and their spares are available in the local markets. This would go a long way to keep the operational efficiency of the vehicle fleet and the equipment functional for optimum use.

a) Handcarts The 6-bin handcarts will be used for the daily door-to-door collection of solid wastes from areas that are not accessible by larger collection vehicles. Each bin will be of 100 litres capacity. Depending on the quantity of wet wastes, 3 or even 4 of the bins will be used for wet wastes and 3 or 2 bins will for dry wastes. The quantity of wastes that will be collected per handcart per trip is 160 kg and the total number of trips done per handcart per day will be 2, thus achieving a high collection rate of 320 kg per handcart per day.



A. 2 BIN HANDCART B. 6 BIN HANDCART C. SIMPLE HANDCART
FIGURE 6-3: DIFFERENT TYPES OF HANDCARTS

b) Pedal Tricycle. Pedal tricycles may also be used for door-to-door collection of solid wastes from areas which are not accessible by larger collection vehicles. The pedal tricycles will carry 4 bins of 100 litres each and a similar collection rate of 150-180 households in a day, as for the handcarts, can be easily achieved.

c) Motor Tricycle with Hydraulic Tipping Container. The motor tricycle is ideally suited for collection from narrow lanes and congested areas where the larger collection vehicles cannot enter or pose a problem for the traffic on the road/lanes. These can give better collection efficiency due to faster travel time than the slower handcarts and pedal tricycles. The motor tricycles can also move faster than larger vehicles through heavy traffic due to its smaller size. The motor tricycles have hydraulic tipping containers mounted on its back with capacities up to 2 cu.m and can collect 700 kg of solid wastes at a time.

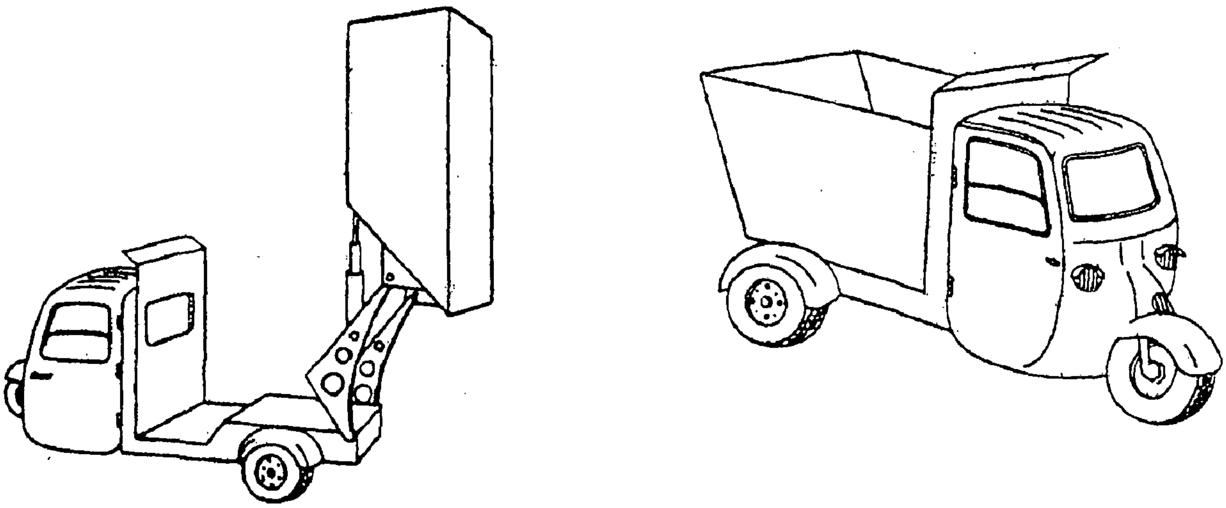
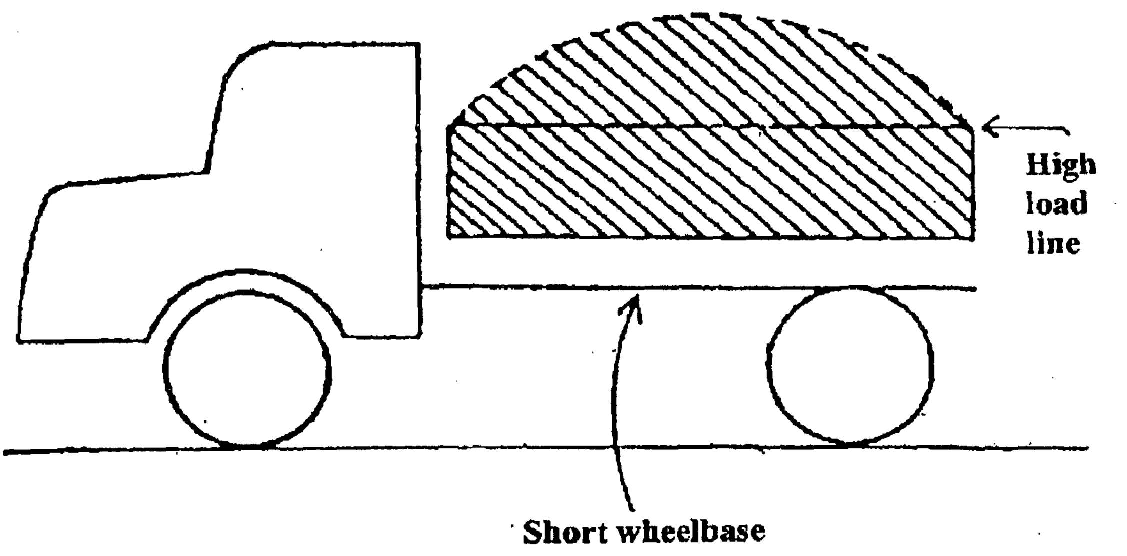


FIGURE 6-4: MOTOR TRICYCLE WITH HYDRAULIC TIPPING CONTAINER

(d) Tipper Trucks. These can be used very effectively for collection of solid wastes from secondary collection points established on the days of large pilgrim influx to Hardwar, on various religious occasions. However, their use for day-to-day secondary collection in Hardwar leads to low collection efficiency for the vehicle. If used for door-to-door collection the waiting time of the vehicle is greatly increased, as the collection crew have to collect from house to house and empty it into the large vehicle. So the best use of tipper trucks can be made at the secondary collection point where waiting time is minimized due to accumulation of large quantity of wastes from primary collection as in the Mela Grounds during various occasions. Also the conventional tipper truck has a few drawbacks which have to be removed by modifying the vehicle slightly for solid wastes collection. The normal tipper trucks have a high load line and a short wheelbase with an open body. When used for solid waste collection it poses a problem for manual loading by SKs since the waste has to be thrown up into the vehicle thereby increasing the probability of littering and also the hazard of the wastes falling on the SKs. This problem of the vehicle can be removed by modifying the vehicle chassis for solid wastes collection. The load line of the vehicle can be reduced by using smaller diameter wheels. Also the capacity of the vehicle can be increased by the provision of a longer wheelbase and increased overhang to the vehicle as shown in Figure 6-5.



(A)

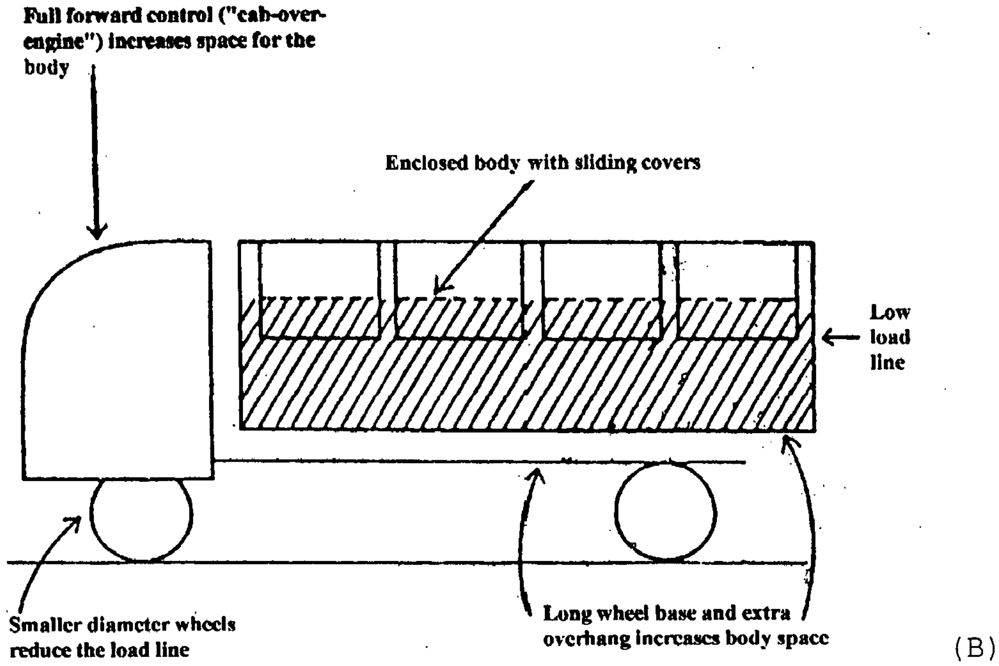


FIGURE 6-5: (A) THE CONVENTIONAL TIPPER TRUCK AND (B) THE MODIFIED TIPPER TRUCK

e) Tractor and Trailers. The tractor is a very widely used motor vehicle in India. The tractor together with a trailer offers one of the cheapest methods of motor transport of solid wastes up to trailer capacity of about 6 m^3 at a time, which would amount to 2 Metric Tonnes of solid wastes.

The tractor and trailer can be used as a coupled unit for the collection of refuse from door-to-door and /or communal storage points. It also can be used as a transfer unit, very effectively, because of the ease with which the prime mover and the trailer can be separated. When separated the tractor can be solely used for the transport of full trailer loaded in its absence and thus it will be fully employed in travelling and in suitable conditions it is possible to transport three to four times the weight per day that could be achieved by the coupled vehicle.

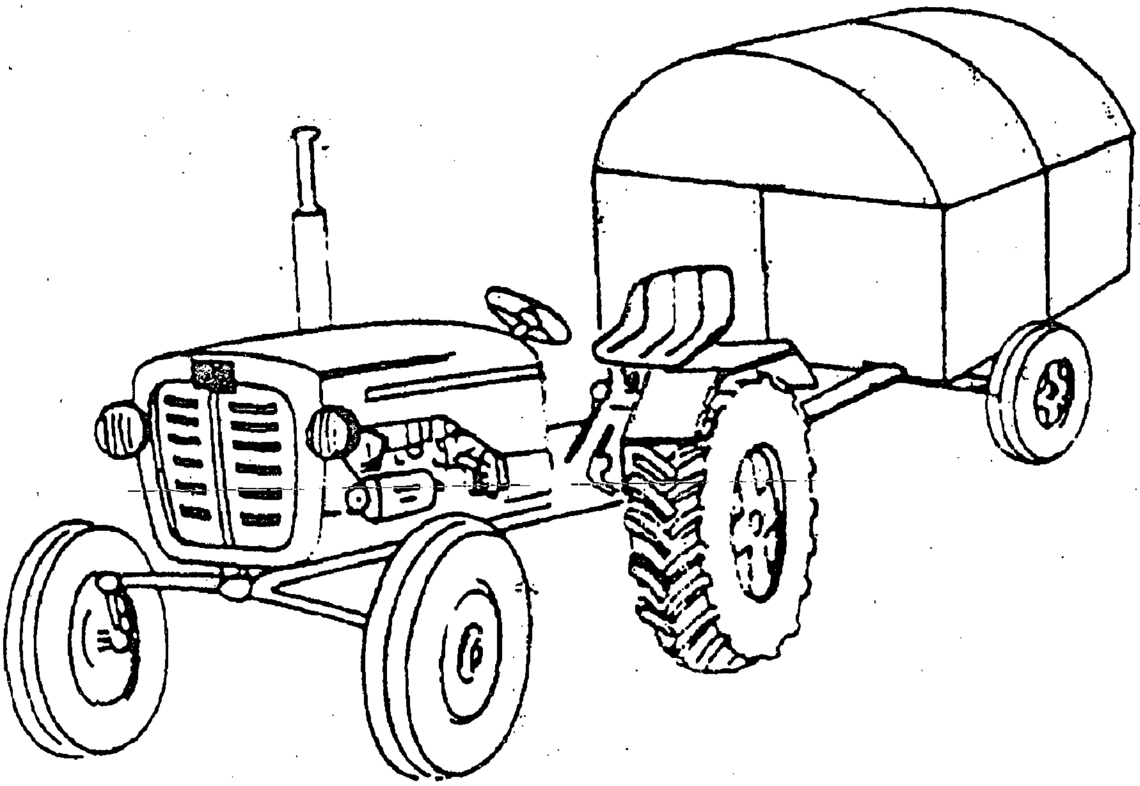
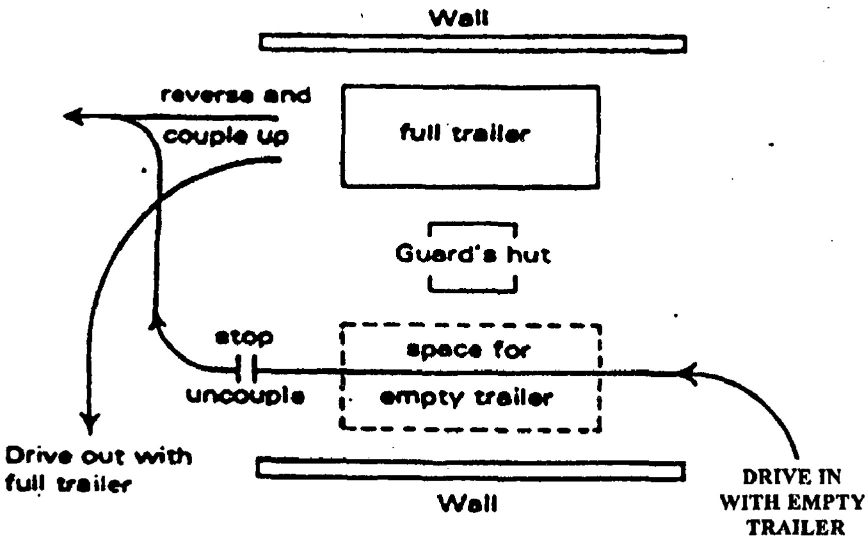


FIGURE 6-6: THE TRACTOR TRAILER COMBINATION FOR SOLID WASTES COLLECTION

The placing of the modified trailers and carrier bins at the sites for communal storage requires certain arrangement to be incorporated in the process of road construction. The ideal arrangement for the placing and transportation of the trailers and bins is shown in the figure below. These arrangements have to be incorporated in the road design and provided along with the roads during road construction. Adequate land must be provided by the development authorities for such arrangements while proposing the new developments.



LAYOUT FOR TRAILER EXCHANGE

LAYOUT FOR CARRIER BIN EXCHANGE

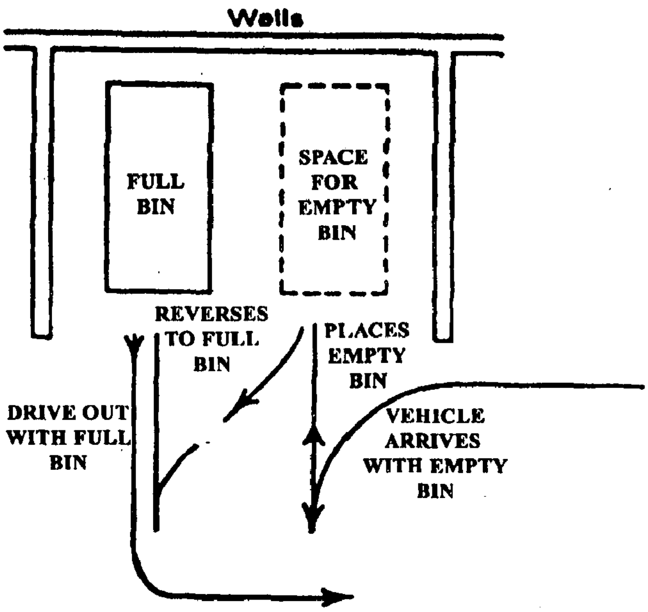


FIGURE 6-7: SITE LAYOUTS FOR TRAILER AND CARRIER BIN EXCHANGE

6.9 VEHICLE, EQUIPMENT AND MANPOWER REQUIREMENTS FOR COLLECTION OF SOLID WASTES IN HARDWAR

We have discussed the different qualitative and quantitative aspects of vehicles and equipment that are required for the seven days a week collection of solid wastes in Hardwar in the preceding sections. With every item there is a requirement of drivers, operators and Safai Karmacharis which needs to be spelt out. The total requirement of various vehicles, equipment and manpower for the SWM in Hardwar is given in the Table below:

EQUIPMENT/VEHICLES	TOTAL NUMBERS REQUIRED	MANPOWER REQUIRED FOR EACH		TOTAL MANPOWER REQUIRED	
		DRIVER/ OPERATOR	SKs	DRIVER/ OPERATOR	SKs
100 LITRE BINS	2716	-	-	-	-
CARRIER BINS	60	-	-	-	-
MODIFIED TRAILERS	30	-	-	-	-
HANDCARTS FOR RESIDENTIAL SW	177	-	01	-	177
HANDCARTS FOR OTHER SW	26	-	02	-	52
MOTOR TRICYCLES FOR RESIDENTIAL SW	27	01	04	27	108
MOTOR TRICYCLES FOR OTHER SW	12	01	02	12	24
TRACTORS FOR TRAILERS	08	01	04	08	32
TRACTORS FOR CBs	15	01	01	15	15
DUMPER PLACER FOR CBs	15	-	-	-	-
SEWER CLEANING MACHINES (02UNITS/MACHINE)	10	02	-	20	-
ROAD SWEEPING	106	-	-	-	106
TOTAL				82	514

TABLE 6-1: VEHICLES, EQUIPMENT AND MANPOWER REQUIREMENT FOR STORAGE AND COLLECTION OF SOLID WASTES IN HARDWAR

Thus we see that the Number of SKs calculated give a figure of 2.18 SKs per thousand of the resident permanent population. This figure confirms well with the WHO standard of 2 to 3 SKs per thousand of population. However even this figure for SKs is low for Hardwar, if we take into consideration the large daily floating population visiting Hardwar.

6.10 EXPENDITURE FOR STORAGE AND COLLECTION EQUIPMENT AND VEHICLES

The expenditure for the storage and collection equipment required for Hardwar is given in the table below.

EQUIPMENT/VEHICLES	COST OF EACH Rs.	TOTAL NUMBERS REQUIRED	TOTAL EXPENDITURE IN LAKHS
100 LITRE BINS	500	2716	135.80
CARRIER BINS	40,000	60	24.00
MODIFIED TRAILERS	60,000	30	18.00
HANDCARTS FOR RESIDENTIAL SW	2,500	177	4.425
HANDCARTS FOR OTHER SW	2,500	26	0.65
MOTOR TRICYCLES FOR RESIDENTIAL SW	2,00,000	27	54.00
MOTOR TRICYCLES FOR OTHER SW	2,00,000	12	24.00
TRACTORS FOR TRAILERS	5,00,000	08	40.00
TRACTORS FOR CBs	5,00,000	15	75.00
DUMPER PLACERS FOR CBs	3,00,000	15	45.00
SEWER CLEANING MACHINES (02UNITS/MACHINE)	5,00,000	10	50.00
TOTAL			470.875

TABLE 6-2: EXPENDITURE FOR PROVIDING STORAGE AND COLLECTION OF SOLD WASTES IN HARDWAR

Thus the total capital expenditure on storage and collection of solid waste in Hardwar for the present population will be Rs. 403 lakhs approximately. With the vehicles, equipment and manpower listed above it is possible to collect all the solid waste being generated in Hardwar presently. The communal storage devices and the SKs will be distributed in all the wards according to the ward population. A suggested distribution of the bins is given below as a guideline for distribution of other facilities, based on the population.

WARD NO.	WARD NAME	WARD POPULATION (projected)	SOLID WASTE GENERATED IN MT/DAY	STORAGE REQUIRED (APPROXIMATE)
1	KADACH	7,170	2.868	02XCB
2	AMBEDHKAR NAGAR	7,851	3.1404	01XMT+01XCB
3	TIBRI	11,095	4.438	03XCB
4	VALMIKI BASTI	8,745	3.498	01XMT+01CB
5	JOGIYA MANDI	8,651	3.4604	01XMT+01XCB
6	RAVIDAS BASTI	9,662	3.8648	02XMT
7	NIRMALA CHAWNI	5,877	2.3508	02XCB
8	KHADKHADI	10,343	4.1372	03XCB
9	MAYAPUR	6,911	2.7644	02XCB
10	MAIDANIYAN	10,602	4.2408	03XCB
11	KOTARWAN	6,088	2.4352	02XCB
12	ACHARYAN	7,099	2.8396	02XCB
13	HAR KI PAIRI	10,343	4.1372	03XCB
14	GAUGHAT	5,407	2.1628	02XCB
15	ME[illegible]TAN	4,067	1.6268	01XCB
16	SH[illegible]AVANNATH NAGAR	6,276	2.5104	02XCB
17	BHOOPATWALA	14,481	5.7924	03XMT
18	ARYA NAGAR	12,506	5.0024	02XMT+01XCB
19	RISHIKUL	8,228	3.2912	01XMT+01XCB
20	KRISHNA NAGAR	1,1143	4.4572	03XCB
21	CHAKLAN	10,108	4.0432	02XMT
22	AWAS VIKAS	9,731	3.8924	02XMT
23	LAKADHARAN	6,794	2.7176	02XCB
24	GOVINDPURI	9,285	3.714	02XMT
25	RAJGHAT	7,640	3.056	02XCB
26	LODHAMANDI	10,884	4.3536	03XCB
27	KASSAWAN	8,087	3.2348	01XMT+01XCB
TOTAL		2,35,074		18XMT+40XCB

TABLE 6-3: STORAGE REQUIREMENT OF INDIVIDUAL WARDS
MT-Modified Trailer
CB-Carrier Bin

Thus we see that in spite of providing additional communal storage capacity to the wards we still have 12 Nos. of Modified Trailers and 20 Nos. of Carrier Bins available out of the total calculated in Section 6.5.1.1. These bins will be placed in the commercial areas, public places and areas most frequented by the tourists. Similarly from the number of households in each ward the requirement of handcarts, motor tricycles and SKs can be worked out.

6.11 SCHEME FOR RECOVERY AND PROCESSING OF SOLID WASTES IN HARDWAR

We have already discussed in Section 3-4 about the unsuitability of the Indian city's solid waste for processes like incineration. However due to the high proportion of biodegradable/putrescible matter in the Indian solid waste it is more amenable to biological processes like composting, vermicomposting etc.

It has already been proposed for the onsite processing of solid wastes that the generators will be responsible for segregation of the solid wastes into wet biodegradable and dry non biodegradable portions. The main purpose of source segregation has been to facilitate the objective of resources and energy recovery from the solid wastes and to reduce the landfilling requirement for the wastes by processing these to reduce their volume and to landfill only that residue of the waste which can no longer be treated or processed.

For Hardwar, Open windrow composting for biodegradable wastes is recommended. With futuristic considerations if we plan for a 200 Metric Tonnes per day input capacity of wastes from households and markets then the following will be the requirements ***(Frank Flintoff, 1984)***:

Total area for windrowing	:	7200 m^2
Plant products	:	120 MT/day Of compost
Storage area required	:	15000m^2
Total land required for the plant Including weighbridge, buildings Work-shops, roads, storage etc.	:	3.22 ha
Total manpower required	:	60

Market price of compost(present) :Rs.500/- to 1000/- per MT

However the operating cost of the composting plants are not available.

Another low cost but effective method available for processing the solid wastes in Hardwar is the Vermicomposting method as discussed in Section 3.4.

6.12 DISPOSAL OF SOLID WASTES IN HARDWAR

Inadequate final disposal (open dumping) of solid wastes thrives because of the mistaken belief that it is the cheapest disposal method. Deposition along roads and riverbanks or in any low lying area and hoping that the waste will go away is both naïve and dangerous. It is inevitable that the chemical and biological contaminants in wastes will find their way back to the humans to affect health, quality of life, and working activities. Soluble and suspended contaminants leaking from the site (leachate) will enter surface watercourses and the groundwater. Contaminants may then directly affect the drinking water supplies and/or the aquatic food chain. Grazing animals on dumps can pass on diseases via the terrestrial food chain, as well as by pests through infestation. Those living near a dump are also at a risk of direct hand-to-mouth transfer of contamination and from the inhalation of volatile compounds and aerosols as shown in the figure below. The details on the common environmental health problems from poor waste management has already been dealt with in the first chapter of this dissertation.

The general philosophy in the minds of some waste managers is that open dumping is acceptable because "we cannot do anything else." This philosophy is misplaced. The protection of the majority of the citizens whose waste is collected and taken away should not be promoted at the expense of the health of those who are at a risk due to the open dumps of solid waste (i.e. those people who live near to the dump or who are vulnerable to the pollution due to the open dump).

The development of an upgraded landfill is neither too difficult nor too expensive, even for a low-income country like ours. An upgraded landfill has been estimated, by some experts, as being three to eight times more expensive than open dumping, the variation attributed to the difference in costs between the following:

a) making only modest improvements away from open dumping and

b) making large changes and developing a sophisticated engineered landfill ***(Rushbrook, Philip, et el, 1999)***.

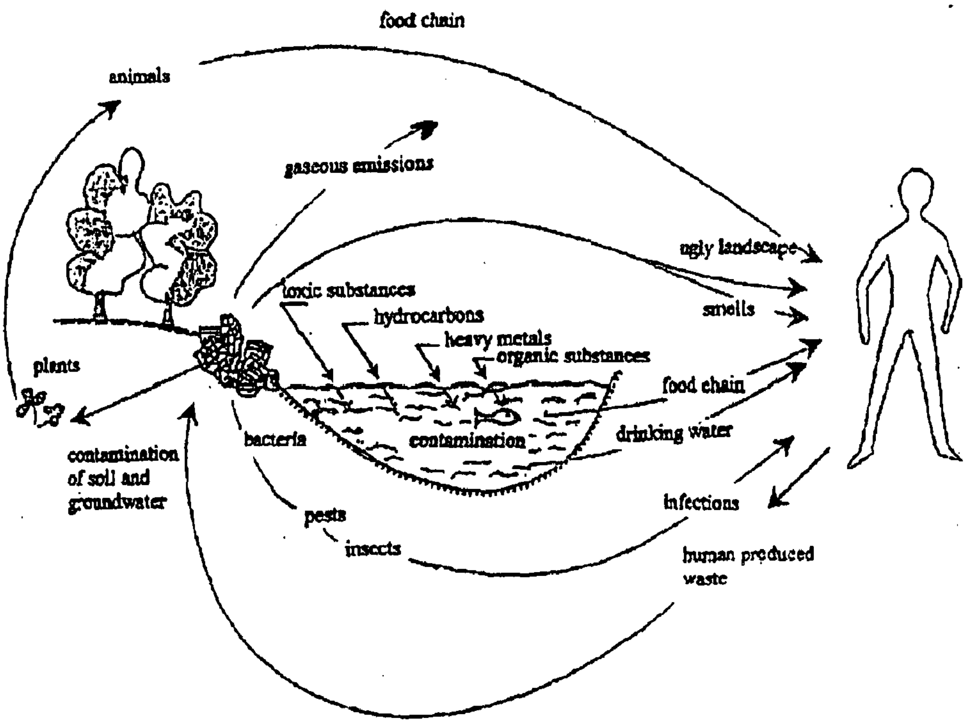


FIGURE 6-7: ROUTES OF EXPOSURE TO HAZARDS CAUSED BY OPEN DUMPING.
(Source: Rushbrook, Philip, et el, 1999)

It has been calculated that an upgraded landfill in low-income countries costs between US$ 3 and 10 per metric ton (at 1995 prices). It might therefore be inferred that the cost of operating an open dump in low-income countries is about US$1 per metric ton. However, the full cost of open dumping is probably much higher if the indirect costs of effects from environmental pollution, loss in land values, and treating people made sick by infections from the wastes are also taken into account.

It is possible to make significant improvements by using, in a different way, the staff, equipment, and finance currently available. The improvement of landfill practice can be a step-by-step process. There are no set piece solutions because designs vary depending on local conditions, but all should represent a progressive improvement over open dumping. It is mandatory as a first step to recognize those parts of the present landfilling operations that are unsanitary and make efforts to rectify them.

As discussed in Section 2.9, the landfill is an engineered facility and has to be dealt with in a professional manner by planners, engineers and concerned municipality authorities. However as brought out in Section 5.8 earlier the disposal of solid wastes in Hardwar is carried out with scant regard to public health, environment and the impact on the flora and fauna around the site.

The foremost requirement for landfilling in the SWM scenario where the solid wastes are treated to processes like composting or incineration is to determine the quantity of wastes that have to be finally landfilled. The probable land requirement for sanitary landfilling of untreated wastes compared with the space required for residues of various treatment processes is given in the figure below. Thus, for every one Metric Ton of solid wastes which are composted, and occupy a volume of 2.0 m^3 the composting rejects would have a volume of 0.6 m^3 (assuming a density of 500kg/m^3). Thus we find that the volume of the composting residues to be landfilled is to one-third the volume of the unprocessed solid wastes. We have assumed the density of solid wastes in Hardwar to be 350 kg/m^3 and therefore the volumetric reduction of the waste shall be even more, as shown in the figure 6-8 for low density wastes.

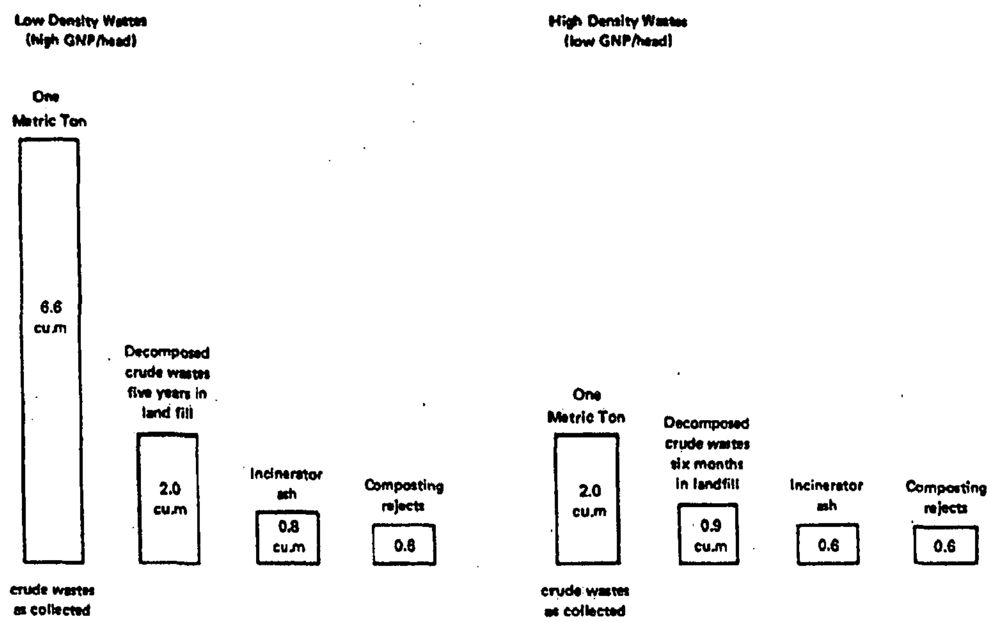


FIGURE 6-8: LAND REQUIREMENT FOR LANDFILLING
(Source: Frank Flintoff, 1984)

Assuming that 75% of the total wastes generated in Hardwar is compostable/fermentable we get the following figures pertaining to landfilling:

Volume of total solid wastes generated In Hardwar @ 350 kg/m^3	:	488.6 m^3
Total Compostable solid wastes per day @ 75% of 171 MT/day	:	128.25 MT = 129.0 MT
Volume of Total compost residues @ 33% of total compostable solid wastes	:	163 m^3
Assuming landfilling height of 2 m/day	:	81.5 m^2 = 82.0 m^2

It is assumed that cells of 2m height are constructed for a period of a month before increasing the height of the landfill.

Area required for a period of one month : 2460 m^2

Thus depending upon the height to which the landfill can be raised at a site the area can be calculated.

The site proposed for landfilling of Solid wastes/residues of waste processing are shown in Map 9. One of the proposed site is in the administrative boundary of the Bharat Heavy Electricals Limited (B.H.E.L.) industrial township, and is already being used for the open dumping of solid wastes from B.H.E.L. The site has an area of 8 hectares approximately and will be able to accept the wastes from Hardwar for a period of 03 years approximately, in addition to the wastes of B.H.E.L. if it is raised to a height of 04 metres. The site has enough cover material available for the solid wastes and so the cover material will not have to be brought from outside. However, the acquisition of site for landfilling by the NPP, Hardwar may pose certain problem as the industrial township land belongs to the Central government and has to be denotified for acquisition by the State government of Uttaranchal. The site will also have to be fenced/walled due to the proximity of the main road.

The second site proposed for disposal of solid wastes and process residues is located at the present landfill site but this site requires greater control and monitoring due to the close proximity of the river Ganga and the Eastern Ganga canal. The site is ideally suited for landfilling as it is low lying and can be filled to an average height of 4 metres approximately. The area of the site is 15 hectares approximately and can be used for a period of 05 to 06 years approximately. The site is accessible by the vehicles through the service track of the canal. However, there is no cover material available at the site and therefore cover material too will have to be brought from other site. Although the site has been in use for the last 03 years, it is not protected from unauthorised entry due to the absence of any wall or fencing.

DAILY TONNAGE OF SOLID WASTES	EQUIPMENT REQUIRED		NUMBERS REQUIRED
	TYPE	ACCESSORY	
0 TO 46	TRACTOR CRAWLER OR RUBBER-TIRED	DOZER BLADE LANDFILL BLADE FRONT-END LOADER	1
46 TO 155	TRACTOR CRAWLER OR RUBBER-TIRED SCRAPER DRAGLINE WATER TRUCK	DOZER BLADE LANDFILL BLADE FRONT-END LOADER	1
155 TO 310	TRACTOR CRAWLER OR RUBBER-TIRED SCRAPER DRAGLINE WATER TRUCK	DOZER BLADE LANDILL BLADE FRONT-END LAODER MULTIPURPOSE BUCKET	1 TO 2
310 OR MORE	TRACTOR CRAWLER OR RUBBER-TIRED SCRAPER DRAGLINE STEEL-WHEEL COMPACTOR ROAD GRADER WATER TRUCK	DOZER BLADE LANDFILL BLADE FRONT-END LOADER BULTIPURPOSE BUCKET	2 OR MORE

TABLE 6-4: EQUIPMENT REQUIRED FOR LANDFILLING OF SOLID WASTES
(Source: Wilson, D.G., 1977)

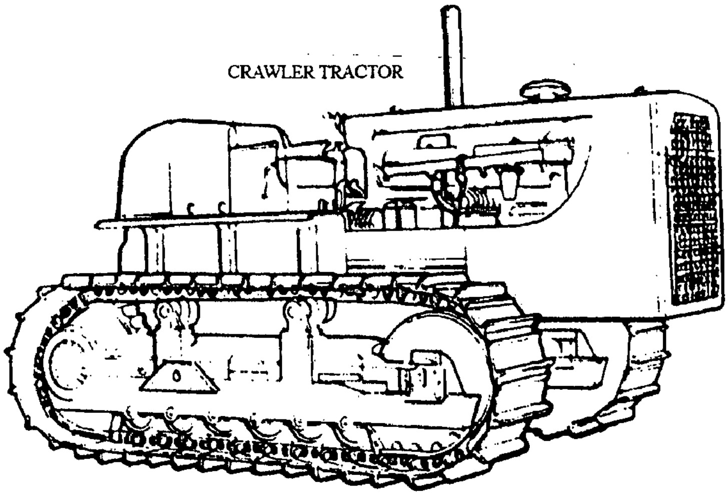
The different types of equipment required for a landfill are tabulated in Table 6-3 above and the equipments are shown in Figure 6-9.

The equipment requirement for the solid wastes to be landfilled in Hardwar are given in the table below along with the expenditure for the equipment. It is assumed that at a time only one landfill site will be used for the disposal of the wastes.

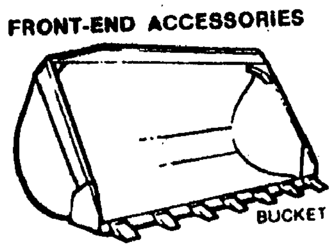
TYPE OF EQUIPMENT	Nos.	UNIT COST(in Rs. Lakhs)	EXPENDITURE In Rs. Lakhs
TRACTOR CRAWLER	02	20.00	40.00
DOZER BLADE	02	1.00	2.00
LANDFILL BLADE	02	1.00	2.00
MULTI PURPOSE BUCKET	02	1.00	2.00
TOTAL			46.00

TABLE 6-5: EXPENDITURE FOR LANDFILLING EQUIPMENT FOR HARDWAR

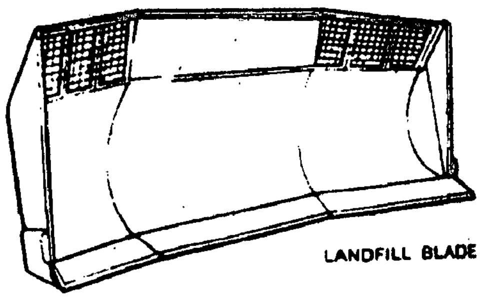
Thus the capital investment required for the equipment needed for the disposal of solid wastes by landfilling is Rs. 46 Lakhs. In addition to this there would be a requirement of building a fence/wall around the landfill site, installation of weighbridge, offices for the landfill staff, garage/parking space for the landfill equipment and control rooms/laboratories for the monitoring the landfill gases and leachate. All this would entail expenditure, for which resources have to be mustered by the NPP, Hardwar.



A. CRAWLER TRACTOR



B. BUCKET



C. LANDFILL BUCKET

FIGURE 6-10: LANDFILL EQUIPMENT PROPOSED FOR HARDWAR

6.13 RESOURCE POTENTIAL OF SOLID WASTES IN HARDWAR

The resource potential of reusable and recyclable wastes, even in the absence of formal framework for such operations is reckonable even for the quantity of wastes generated in Hardwar. We consider the following average composition of waste in Hardwar:

Component	Percentage
Paper	3.0-10
Plastic	1.0-5.0
Metals	0.4-1.0
Glass	0.3-1.0
Ash and fine earth	30-50
Total organic fractions	30-50

Table 6-6: COMPOSITION OF INDIAN CITY REFUSE
(Source: Bhide, A.D., et el, 1983)

If we take the optimal percentages of the various components then we get the following quantities of the components from 142 metric tonnes of Hardwar's solid wastes as shown in the table below.

Components	Percentage	Quantity produced per day (Metric Tonnes)	Recyclable @10%
Paper	10	14.2	1.42
Plastics	5.0	7.125	0.7125
Metals	1.0	1.42	0.142
Glass	1.0	1.42	0.142

TABLE 6-7: QUANTITIES OF VARIOUS COMPONENTS IN SOLID WASTES OF HARDWAR

The resource/economic potential of the recyclable materials can be roughly estimated from the resale rates of the materials as shown in the table 6-8.

The rates which have been taken are the lowest rates paid to ragpickers for the type of component and do not reflect the actual earnings of a ragpicker since each component includes a number of items which are sold at much higher rates egg. Brass is sold at Rs.40.00 to Rs.50.00 per kg. By the ragpickers, similarly the plastic milk covers are sold for Rs.10.00 to Rs.12.00 per kg. These rates have been obtainer from ragpickers, raddiwalas and kabadiwalas in Hardwar and Roorkee.

Component	Recyclable quantity/day (in kgs.)	Rate per kg. (in Rs.)	Total value (in Rs.)
Paper	1,420	2.00	2840.00
Plastic	712.5	8.00	5700.00
Metal	142	5.00	710.00
Glass	142	0.75	71.00
Total			9321.00

TABLE 6-8: RESOURCE POTENTIAL OF WASTES IN HARDWAR

Thus even at a low recycling rate of 10% we find that materials worth Rs.10,000.00 approximately can retrieved from the commingled solid wastes of Hardwar every day, even in the absence of any formal recycling operations. This amounts to a significant amount of Rs. 36.50 Lakhs in a year. It is obvious that significantly higher recycling rates and therefore monetary gains, can be attained by formal recycling and recovery operations. Therefore the formalization of recycling and recovery operations can go a long way to ease the financial burden of the urban local body i.e. the NPP Hardwar.

Since the NPP, Hardwar has been unable to provide the required quality of service in respect of SWM, due to reasons of financial crunch, inefficiency, corruption and lack of accountability on the part of the government and elected representatives, there is a need to change the level of involvement of the NPP, in the provision of various services. The option of involving the private sector in SWM of a city has already been discussed in Section 3.11 and the various options for the privatisation of SWM in Hardwar need to be considered to bring about a change in the deteriorating environmental and public health conditions due to the sub standard, inadequate and improper solid waste management.

6.14 PRIVATISATION OF SOLID WASTE MANAGEMENT IN HARDWAR

The privatisation of the SWM in Hardwar has to be phased to bring about a decrease in the involvement of the NPP, Hardwar in the execution aspects of solid waste management. The NPP should act as a regulating and monitoring agency rather than an executing body for the provision of the infrastructural services. The SWM services categorised into the six functional elements should be gradually privatised in a phased manner. The priority for the phasing of the SWM services can be as follows:

(a) Priority I- Door to door, primary collection from sources.

(b) Priority II- Secondary collection from the communal storage bins.

(c) Priority III- Processing, Treatment and Recovery operations.

(d) Priority IV- Disposal of Process residues.

The introduction of privatisation in the SWM plan of Hardwar implies that the service can no longer be provided free of cost to the citizens. In addition the private company would venture into the field only if it is profitable for it. However the privatisation of SWM in Hardwar can be made a economically viable option for the private companies, if there is a provision for levying fees/charges from the beneficiaries of the SWM service. The following tables provide an insight into the economic implications of the process.

TYPE OF HOUSEHOLD	% OF TOTAL	NUMBERS	RATE (Rs.) PER MONTH	TOTAL REVENUE (Rs.) PER MONTH
HIG	20	9,403	50.00	4,70,150.00
MIG	30	14,105	30.00	4,23,150.00
LIG AND EWS	50	23,508	05.00	1,17,540.00
TOTAL	100	47,105		10,10,840.00

TABLE 6-9: REVENUE FROM HOUSEHOLDS

Thus by levying nominal charges from the households, Rs. 121,30,080.00 i.e. almost 121.50 lakhs can be generated as revenue for SWM.

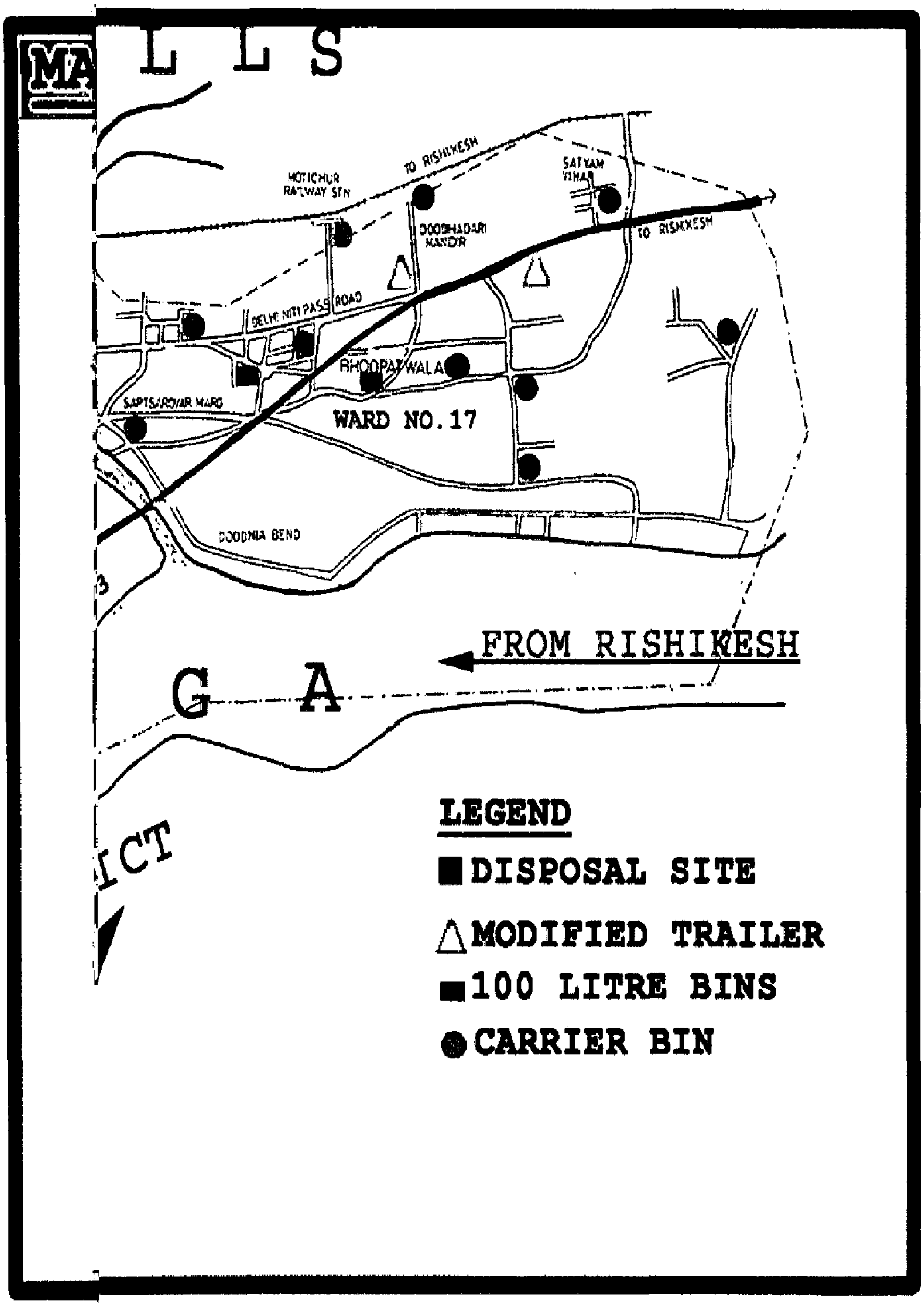
Similarly from the commercial establishments revenue for SWM can be generated as shown in Table 6-9.

TYPE OF COMMERCIAL ESTABLISHMENT	NUMBERS	RATE(Rs.) PER MONTH	TOTAL REVENUE(Rs.)
HOTELS	125	200.00	25,000.00
DHARAMSHALAS	120	100.00	12,000.00
REST HOUSES	07	50.00	350.00
DAK BUNGLOWS	15	50.00	750.00
RESTAURANTS BIG	19	100.00	1900.00
RESTAURANTS SMALL	50	50.00	2500.00
SHOPS SMALL < =100SQ FT	1000	25.00	25,000.00
SHOPS > 100 SQ FT	500	50.00	25,000.00
TOTAL			92,500.00

TABLE 6-9: REVENUE FROM COMMERCIAL ESTABLISHMENTS

This a revenue of more than Rs. 11 lakhs can be generated from the commercial establishments in Hardwar.

Thus we find that the expenditure incurred by the Municipality and the revenue generated from the beneficiaries of the SWM service together can make the city of Hardwar free from garbage.


MA
L L S
MOTICHUR RAILWAY STN
TO RISHIKESH
SATYAM VIHAR
DOODHADARI MANDIR
TO RISHIKESH
DELHI NITI PASS ROAD
BHOOPATWALA
SAPTSAROVAR MARG
WARD NO.17
DOODHIA BEND
3
FROM RISHIKESH
G A
ICT
LEGEND
DISPOSAL SITE
MODIFIED TRAILER
100 LITRE BINS
CARRIER BIN

CHAPTER 7

PLANNING GUIDELINES FOR IMPLEMENTATION OF SUSTAINABLE SWM PROGRAMMES IN URBAN AREAS

7.1 GENERAL

From all our studies and experiences in solid waste management, it becomes pertinent to draw lessons and inferences, which can be considered as guidelines for any development of the urban form.

In the world of market economy, it is becoming more and more evident that as the economic conditions of the population increases, the government's contribution towards providing free services for the people cannot continue to be as high as it is today. The governments of the day and the communities have to realise and accept that like many of the essential services like water supply, electricity etc., which are available to the public at a cost, the other services like sewage disposal, solid waste management etc. will also have to be paid for, if the public wants to enjoy the benefits of a cleaner, healthier and better urban environment.

It is also a very natural phenomenon that once the beneficiaries of a service pay for it, they have a consumer's right to accept only the best of standards. The agency responsible for providing the service also is accountable to its clients.

It is in the light of these concepts of urban services, that the following planning implications are brought out for consideration by the urban planners and managers.

1. The roads in any new urban development have to be planned to cater for the solid waste management facilities like the bins/waste receptacles etc.

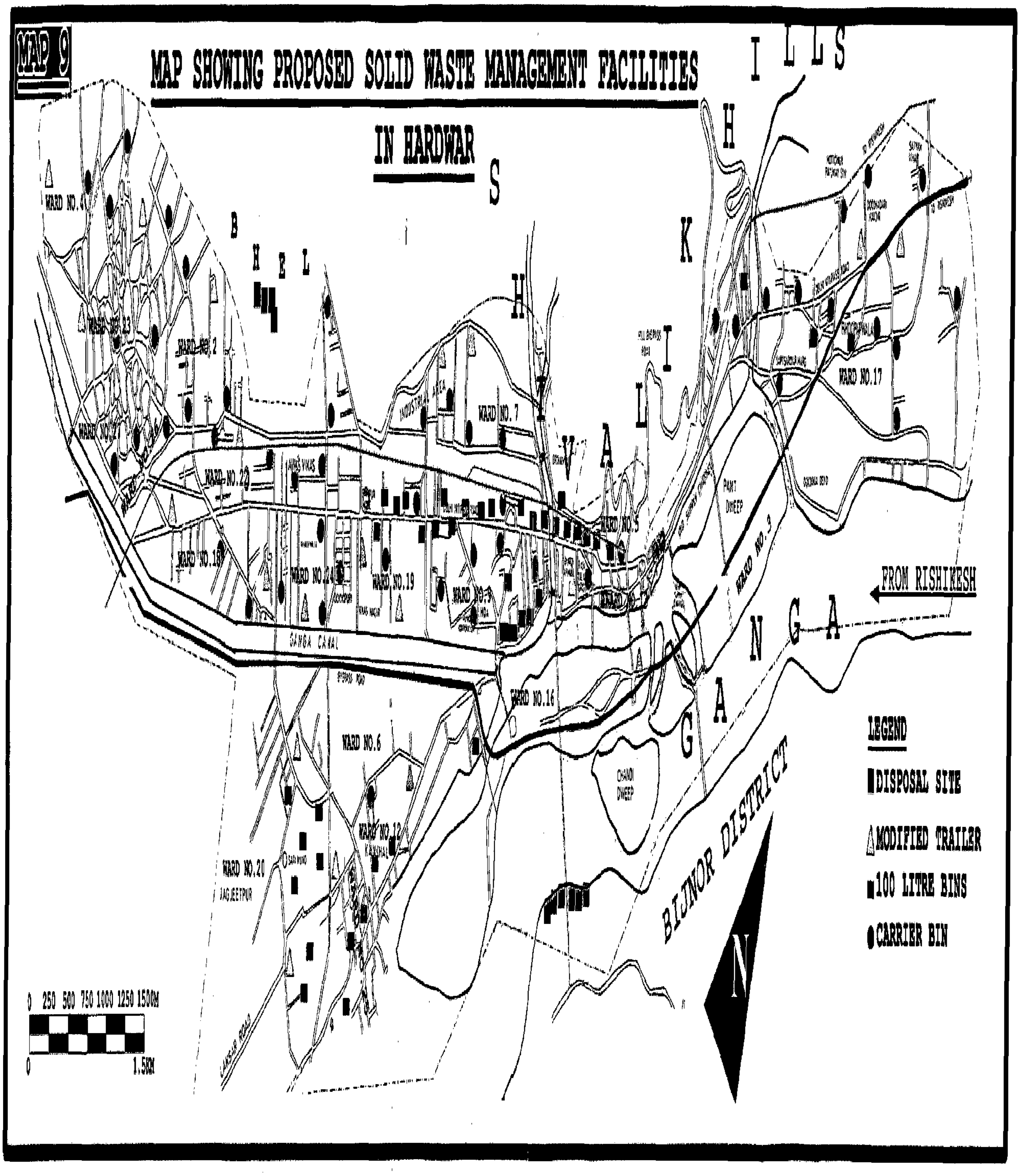
2. It is necessary to cater for the large quantity of construction and demolition debris generated in the urban areas. The development authorities have to earmarked appropriate sites for reclamation by the landfilling of construction and demolition debris.

3. The governments of the day, the urban managers and the population has to seriously rethink the control and regulation of plastic products and mainly its recycling. Numerous studies in the western countries have shown that the non-biodegradability and toxicity of the degraded plastics is severely damaging the environment. In the case of our cities too, this menace is assuming enormous proportions and has to immediately taken care of before that damages become extensive. Effective legislations for monitoring the quality of recycled plastics and strict control on the plastic products would be correct step under the present scenario.

5. Littering of wastes has already been made punishable in some of the cities, this needs to be extended to all urban areas immediately to prevent any further degradation of the urban environment. This becomes more pertinent in light of the deficient solid waste management services in most Indian cities.

6. In areas like Hardwar where there is a massive quantity of silt accumulation due to the seasonal streams, measures like extensive afforestation have to be implemented in the surrounding hill areas to prevent further erosion of the soil cover of the hills and restore the green cover.

7. It is pertinent to involve the communities in the SWM programmes to make the programmes successful. The media needs to be effectively utilised by the government and the urban planners and managers to create awareness in the citizens regarding the measures undertaken by


MAP 9
MAP SHOWING PROPOSED SOLID WASTE MANAGEMENT FACILITIES
IN HARDWAR
SHIVALIK HILLS
BHEL
WARD NO.4
WARD NO.23
WARD NO.2
WARD NO.21
WARD NO.22
WARD NO.18
WARD NO.24
WARD NO.19
WARD NO.7
WARD NO.5
WARD NO.17
WARD NO.3
WARD NO.16
WARD NO.6
WARD NO.12
WARD NO.20
INDUSTRIAL AREA
GANGA CANAL
PANT DWEEP
CHANDI DWEEP
GANGA
FROM RISHIKESH
BIJNOR DISTRICT
LEGEND
DISPOSAL SITE
MODIFIED TRAILER
100 LITRE BINS
CARRIER BIN
0 250 500 750 1000 1250 1500M
0 1.5KM
N

1. The roads in any new urban development have to be planned to cater for the solid waste management facilities like the bins/waste receptacles etc.

2. It is necessary to cater for the large quantity of construction and demolition debris generated in the urban areas. The development authorities have to earmarked appropriate sites for reclamation by the landfilling of construction and demolition debris.

3. The governments of the day, the urban managers and the population has to seriously rethink the control and regulation of plastic products and mainly its recycling. Numerous studies in the western countries have shown that the non-biodegradability and toxicity of the degraded plastics is severely damaging the environment. In the case of our cities too, this menace is assuming enormous proportions and has to immediately taken care of before that damages become extensive. Effective legislations for monitoring the quality of recycled plastics and strict control on the plastic products would be correct step under the present scenario.

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7. It is pertinent to involve the communities in the SWM programmes to make the programmes successful. The media needs to be effectively utilised by the government and the urban planners and managers to create awareness in the citizens regarding the measures undertaken by

the various agencies, and the role of the communities, for the betterment of the cities.

8. It is also essential to reinforce the traditional practices of reuse and recycling in the Indian communities to keep the waste generation at a minimum. The Indian ethos of least wastage of any resource whatsoever needs to be imbibed by the population. The various government and non government agencies should promote such programmes at the community level which not only creates awareness , but also effects waste minimisation.

GLOSSARY

Aerobic. A biochemical process or environmental condition occurring in the presence of oxygen.

Agricultural Solid Wastes produced from the raising of plants and animals for food, including manure, plant stalks, hulls, and leaves.

Anaerobic. A biochemical process or environmental condition occurring in the absence of oxygen.

Ash. The incombustible material that remains after a fuel or solid waste has been burned.

At-site time. The time spent unloading and waiting to unload the contents of a collection vehicle or loaded container at a transfer station, processing facility, or disposal site.

Bacteria. Single-cell, microscopic organisms with rigid cell walls. They may be aerobic, anaerobic, or facultative anaerobic; some can cause disease; and some are important in the stabilization and conversion of solid wastes.

Biodegradable Material. A compound that can be degraded or converted to simpler compounds by micro-organisms.

Biodegradable Volatile Solids (BVS). The portion of the volatile solids of the organic matter in MSW that is biodegradable.

Bulky Waste. Large wastes such as appliances, furniture, some automobile parts, trees and branches, palm fronds, and stumps.

Buy-Back Centre. A physical facility where individuals can bring back recyclable materials in exchange for payment.

Carbonaceous Matter. Pure carbon or carbon compounds present in solid wastes.

Carbon dioxide (CO2). A colourless, odourless, nonpoisonous gas that forms carbonic acid when dissolved in water. It is produced during the thermal degradation and microbial decomposition of solid wastes.

Carbon monoxide (CO) A colourless, poisonous gas that has an exceedingly faint metallic odour and taste. It is produced during the thermal degradation and microbial decomposition of solid wastes when the oxygen supply is limited.

Cell. The term is used to describe the volume of material placed in a landfill during one operating period, usually one day. A cell includes the solid waste deposited and the daily cover material surrounding it. Daily cover usually consists of 6 to 12 inches of soil or alternative material, such as compost, that are applied to the working faces of the landfill at the end of each operating period. The purpose of daily cover are to control the blowing of waste materials, to prevent rats, flies and other disease vectors from entering or exiting the landfill and to control the entry of water into the landfill during operation.

Collection, waste. The act of picking up wastes at homes, businesses, commercial and industrial plants, and other locations; loading them into a collection vehicle (usually enclosed); and hauling them to a facility for further processing or transfer or to a disposal site.

Collection routes. The established routes followed in the collection of commingled and source-separated wastes from homes, businesses, commercial and industrial plants, and other locations.

Collection systems. Collectors and equipment used for the collection of commingled and source-separated waste. Waste collection systems may be classified from several points of view, such as the mode of operation, the equipment used, and the types of wastes collected. In this text, collection systems have been classified according to their mode of operation into two categories; hauled container systems and stationary container systems.

Combustible materials. Various materials in the waste stream that are combustible. In general, they are organic in nature (e.g. food waste, paper, cardboard, plastics, yard wastes).

Combustion. The chemical combining of oxygen with a substance, which results in the production of heat and usually light.

Commercial solid wastes. Wastes that originate in wholesale, retail, or service establishments, such as office buildings, stores, markets, theaters, hotels, and warehouses.

Commingled recyclables. A mixture of several recyclable materials in one container.

Commingled waste. Mixture of all waste components in one container.

Compactor. Any power-driven mechanical equipment designed to compress and thereby reduce the volume of wastes.

Compaction. (see Densification)

Compactor collection vehicle. A large vehicle with an enclosed body having special power-driven equipment for loading, compressing, and distributing wastes within the body.

Component separation. The separation or sorting of wastes into components or categories.

Compost. A mixture of organic wastes partially decomposed by aerobic and /or anaerobic bacteria to an intermediate state. Compost can be used as a soil conditioner.

Composting. The controlled biological decomposition of organic solid waste materials under aerobic conditions. Composting can be accomplished in windrows, static piles, and enclosed vessels (known as in-vessel composting).

Construction wastes. Wastes produced in the course of construction of homes, office buildings, dams, industrial plants, schools, and other structures. The materials usually include used lumber, miscellaneous metal parts, packaging materials, cans, boxes, wire, excess sheet metal, and other materials. Construction and demolition wastes are usually grouped together.

Container. A receptacle used for the storage of solid wastes until they are collected.

Conversion. The transformation of wastes into other forms; for example, transformation by burning or pyrolysis into steam, gas, or oil.

Conversion products. Products derived from the first-step conversion of solid wastes, such as heat from combustion and gas from biological conversion.

Cover material. Soil or other material used to cover compacted solid wastes in a sanitary landfill.

Cullet clean. Generally colour-sorted, crushed glass used in the manufacture of new glass products.

Curbside collection. The collection of source-separated and mixed wastes from the curbside where they have been placed by the resident.

Decomposition. The breakdown or organic wastes by bacterial, chemical, or thermal means. Complete chemical oxidation leaves only carbon dioxide, water, and inorganic solids.

Demolition wastes. Wastes produced from the demolition of buildings, roads, sidewalks, and other structures. These wastes usually include large, broken pieces of concrete, pipe, radiators, duct work, electrical wire, broken-up plaster walls, lighting fixtures, bricks and glass.

Densification. The unit operation used to increase the specific weight (density in metric units) of waste materials so that they can be stored and transported more efficiently.

Dewatering. The removal of water conversion of processed organic wastes to methane and carbon dioxide under anaerobic conditions.

Digestion, anaerobic. The biological conversion of processed organic wastes to methane and carbon dioxide under anaerobic conditions.

Disposal. The activities associated with the long-term handling of (1) solid wastes that are collected and are of no further use and (2) the residual matter after solid wastes have been processed and the recovery of conversion products or energy has been accomplished. Normally, disposal is accomplished by means of sanitary landfilling.

Diversion rate. A measure of the amount of material now being diverted for recovery and recycling compared to the total amount of waste that was thrown away previously.

Drop-off centre. A location where residents or businesses bring source-separate recyclable materials. Drop-off centre range from single-material collection points (e.g., easy-access "igloo" containers) to staffed, multilateral collection centres.

Effluent. Any solid, liquid, or gas that enters the environment as a by-product of human activities.

Endemic plant. Plant species that is confined to a specific location, region, or habitat.

Energy recovery. The process of recovering energy from the conversion products derived from solid wastes, such as the heat produced from the burning of solid wastes.

Environmental monitoring involves the activities associated with collection and analysis of water and air samples, that are used to monitor the movement of landfill gases and leachate at the landfill site. Landfill closure is the term used to describe the steps that must be taken to close and secure a landfill site once the filling operations has been completed.

Ferrous metals. Metals composed predominantly of iron, in the waste materials stream. These metals usually include tin cans, automobiles, refrigerators, stoves, and other appliances.

Final cover. This usually consists of multiple layers of soil and /or geomembrane materials designed to enhance surface drainage, intercept percolating water and support surface vegetation in a landfill.

Flow diagram, process. A diagram in which is shown the assemblage of unit operations, facilities, and manual operations used to achieve a specified waste separation goal or goals.

Fly ash. Small solid particles of ash and soot generated when coal, or solid wastes are burned. With proper equipment, fly ash is collected before in enters the atmosphere. Fly ash residue can be used for building material (bricks) or in a sanitary landfill.

Food wastes. Animal and vegetable wastes resulting from the handling, storage, sale. Preparation, cooking, and serving of foods; commonly called garbage.

Functional element. The term functional element is used in this text to describe the various activities associated with the management of solid wastes from the point of generation to final disposal. In general, a functional element represents a physical activity. The six functional elements used throughout this report are waste generation; waste handling, separation, storage and processing at the source; collection separation and processing and transformation of solid waste; transfer and transport; and disposal.

Garbage (see Food Wastes).

Generation (see Food Generation).

Groundwater. Water beneath the surface of the earth and located between saturated soil and rock. It is the water that supplies wells and springs.

Haul distance. The distance a collection vehicle travels (1) after picking up a loaded container (hauled container system) or from its last pickup stop on a collection route (stationary container system) to a materials recovery facility. Transfer station, or sanitary landfill, and (2) the distance the collection vehicle travels after unloading to the location where the empty container is to be deposited or to the beginning of a new collection route.

Haul time. The elapsed or cumulative time spent transporting solid wastes between two specific locations.

Hauled container system. Collection systems in which the containers used for the storage of wastes are hauled to the disposal site, emptied, and returned to either their original location or some other location.

Hazardous wastes. Wastes that by their nature may pose a threat to human health or the environment, the handling and disposal of which is regulated by federal law. Hazardous wastes include radioactive substances, toxic chemicals, biological wastes, flammable wastes, and explosives.

Heavy metals. Metals such as cadmium, lead, and mercury which way be found in MSW in discarded items such is batteries, lighting fixtures, colorants and inks.

Hierarchy Of Integrated Solid Waste Management. Source reduction, recycling, waste transformation, and disposal. It should be noted that EPA uses the term combustion instead of transformation. Further, EPA does not make a distinction between waste transformation (combustion) and disposal, as both are viewed as viable components of an integrated waste management program. A distinction is made between transformation and disposal in some states.

Hydrogen sulfide (H2S). A poisonous gas with the odour of rotten eggs that is produced from the reduction of sulfates in, and the putrefaction of, a sulfur-containing organic material.

Incineration. The controlled process by which solid, liquid, or graseous combustible wastes are burned and changed into gases, and the residue produced contains little or no combustible material. Incineration is referred to as combustion in this text.

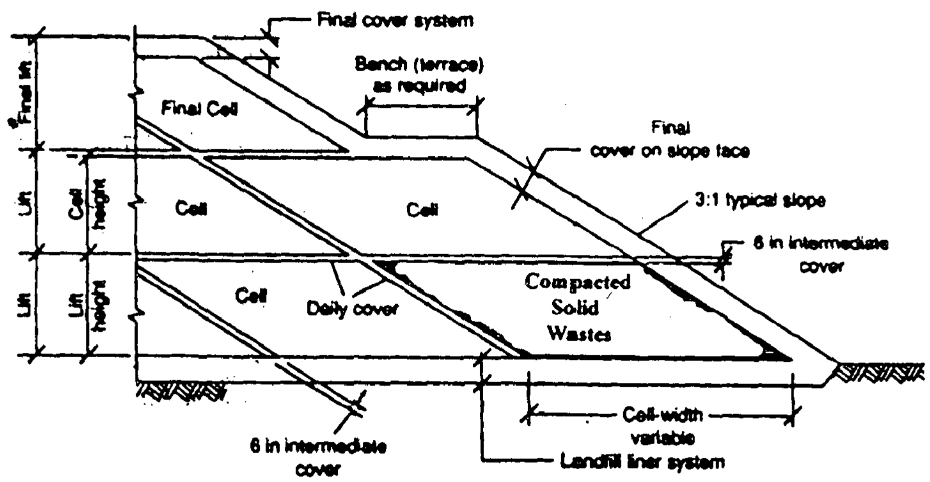
Industrial Wastes. Wastes generally discarded from industrial operations or derived from manufacturing processes. A distinction should be made between scrap (those materials that can be recycled at a profit) and solid wastes (those that are beyond the reach of economical reclamation).

Integrated Solid Waste Management. The management of solid waste based on a consideration of source reduction. Recycling, waste transformation, and disposal arranged in a hierarchical order. The purposeful, systematic control of the functional elements of generation; waste handling, separation, and processing at the source; collection; separation and processing and transformation of solid waste; transfer and transport; and disposal associated with the management of solid wastes from the point of generation to final disposal.

Landfill control facilities include liners, landfill leachate collection and extraction systems, landfill gas collection and extraction systems, and daily and final cover layers.

Landfill gas is the mixture of gases found within a landfill. The bulk of landfill gas consists of methane (CH4) and carbondioxide (CO2), the principal products of the anaerobic decomposition of the biodegradeable organic fraction of the MSW in the landfill. Other components of the landfill gas include atmospheric nitrogen and oxygen, ammonia and trace organic compounds.

Landfilling is the process by which residual solid waste is placed in a landfill. Landfilling includes monitoring of the incoming waste stream, placement and compaction of the waste and installation of landfill environmental monitoring and control facilities. The various components are shown in the cross sectional view of a landfill in Figure.



Landfill liners are materials (both natural and manufactured) that are used to line the bottom area and below-grade sides of a landfill).

Leachate Liquid. The percolate through solid waste or another medium. Leachate from landfills usually contains extracted, dissolved and suspended materials, some of which may be harmful. In general, leachate is a result of percolation of precipitation, uncontrolled runoff and irrigation water into the landfill. Leachate can also include water initially contained in the waste as well as infiltrating groundwater. Leachate contains a variety of chemical constituents derived from the solubilization of the materials deposited in the landfill and from the products of the chemical and biochemical reactions occurring within the landfill.

Litter. That highly visible portion of solid wastes that is generated by the consumer and carelessly discarded outside the regular disposal system. Litter accounts for only a small percentage of the total solid waste volume.

Magnetic separation. The use of magnets to separate ferrous materials from commingled waste materials in MSW.

Manual separation. The separation of wastes by hand. Sometimes called "hand-picking" or 'hand-sorting", manual separation is done in the home or office by keeping food wastes separate from newspaper, or in a materials recovery facility by picking out large cardboard and other recoverable materials.

Mass burn. The controlled combustion of unseparated commingled. MSW.

Materials Recovery Facility (MRF). The physical facilities used for the further separation and processing of wastes that have been separated at the source and for the separation of commingled wastes.

Materials recovery/transfer facilities (MR/TFs). Multipurpose facilities which may include the functions of a drop-off centre for separated wastes, a materials recovery facility, a facility for the composting and bioconversion of wastes, a facility for the production of refuse-derived fuel, and a transfer and transport facility.

Mechanical separation. The separation of solid wastes into various components by mechanical means.

Methane (CH4). An odourless, colourless, and asphyxiating gas that can explode under certain circumstances and that can be produced by solid wastes undergoing anaerobic decomposition.

Microorganisms. Generally, any living thing microscopic in size, including bacteria, yeasts, simple fungi, actinomycetes, some algae, slime molds, and protozoans. They are involved in stabilization of wastes (composting) and in sewage treatment processes.

Moisture Content. The weight loss (expressed in percent) when a sample of solid wastes is dried to a constant weight at a temperature of 100 to 105oC.

Municipal Solid Wastes (MSW). Includes all the wastes generated from residential households and apartment buildings, commercial and business establishments, institutional facilities, construction and demolition activities, municipal services, and treatment plant sites.

Mulch. Any material, organic or inorganic, applied as a top-dressing layer to the soil surface. Mulch is also placed around plants to limit evaporation of moisture and freezing of roots.

Native plant general term referring to plants that grow in a region.

Nonferrous metals. Metals that

collectors on activities that are nonproductive from the point of view of the overall collection operation.

Onsite Handling Storage, And Processing. The activities associated with the handling, storage, and processing of solid wastes at the source of generation before they are collected.

Organic materials. Chemical compounds containing carbon combined with other chemical elements. Organic materials can be of natural or anthropogenic origin. Most organic compounds are a source of food for bacteria and are usually combustible.

Organic Soil Amendment. Plant and animal residues added to mineral soil to improve soil structure and enhance nutritional content of the soil.

Participation rate. A measure of the number of people participating in a recycling program or other similar program, compared to the total number of people that could be participating.

Pathogen. An organism capable of causing disease. The four major classifications of pathogen found in solid waste are bacteria, virus, protozoas, and helminths.

Pickup time. For a hauled container system, it represents the time spent driving to a loaded container after an empty container has been deposited, plus the time spent picking up the loaded container the time required to redeposit the container after its contents have been emptied, For a stationary container system, it refers to the time spent loading the collection vehicle, beginning with the stopping of the vehicle prior to loading the contents of the first container and ending when the contents of the last container to be emptied have been loaded.

Plant Community. Assemblage of plants coexisting together in a common habitat or environment.

Pollution. The contamination ofsoil, water or the atmosphere by the discharge of wastes or other offensive materials.

Primary materials Virhin or new materials used for manufacturing basic products. Examples include wood pulp, iron ore, and silica sand.

Post closure care refers to the activities associated with the long term monitoring and maintenance of the completed landfill (typically 30 to 50 years).

Processing. Any method, system or other means designated to change the physical form or chemical content of solid wastes.

Putrescible. Subject to biological and chemical decomposition or decay. Usually in reference to food content of solid wastes.

Pyrolysis. A way of breaking down burnable waste by combustion in the absence of air. High heat is usually applied to the wastes in a closed chamber; all moisture evaporates, and materials break down into various hydrocarbon gases and carbonlike residue.

Reclamation. The restoration to a better or more useful state, such is land reclamation by sanitary landfilling, or the extraction of useful materials from solid wastes.

Recoverable resource. Materials that still have useful physical or chemical properties after serving a specific purpose and can, therefore, be reused or recycled for the same or other purpose.

Recovery (see resource recovery)

Recycling. Separating a given waste material (e.g., glass) from the wastestream and processing it so that it may be used again as a useful material for products which may or may not be similar to the original.

Refuse. A term often used interchangeably with the term solid waste. To avoid confusion. The term refuse is not used in this text.

Refuse-derived fuel (RDF). The material remaining after the selected recyclable and noncombustible materials have been removed from MSW.

Residential wastes. Wastes generated in housed and apartments, including paper, cardboard, beverage and food cans, plastics, food wastes, glass containers, and garden wastes.

Residue. The solid materials remaining after the separation of waste materials or after the completion of a chemical or physical process, such as burning, evaporation distillation, or filtration.

Resource recovery. Resource recovery is a general term to describe the extraction of economically usable materials or energy from wastes. The concept may involve recycling or conversion into different and sometimes unrelated uses.

Reuse. The use of a waste material or product more than ones.

Rubbish. A general term for solid wastes-excluding food wastes and ashes-taken from residence, commercial establishments, and institutions.

Sanitary landfill. A engineered method of disposing of solid wastes on land in a manner that protects human health and the environment. Waste is spread in thin layers. Compacted to the smallest practical volume, and covered with soil or other suitable material at the end of each working day.

Screening. A unit operation that is used to separate mixture of materials of different sizes into two or more size fraction by means of one or more screening surface.

Secondary material. A material that is used in place of a primary or raw material in manufacturing a product.

Separation. To divide wastes into groups of similar materials, such as paper products, glass, food wastes, and metals. Also used to describe the further sorting of materials into more specific categories, such as clear glass and dark glass. Separation may be done manually or mechanically with specialized equipment.

Shredding. Mechanical operations used to reduce the size of solid wastes.

Size reduction Mechanical The mechanical conversion of solid wastes into small pieces. In practice, the terms shredding, grinding and milling are used interchangeably to describe mechanical size reduction operations.

Solid waste management (see integrated waste management)

Solid wastes. Any of a wide variety of solid materials, as well as some liquids in containers. Which are discarded or rejected as being spent, useless, worthless, or in excess. Does not usually include waste solids from treatment facilities. See also agricultural, commercial construction, demolition, hazardous, industrial, municipal, and residential wastes.

Source reduction. The design, manufacture, acquisition, and reuse of materials so as to minimize the quantity or toxicity of the waste generated.

Source separation. The separation of waste materials from other commingled wastes at the point of generation.

Source-separated materials. Waste materials that have been separated at the point of generation. Source-separated materials are normally collected separately.

Special wastes. Special wastes include bulky items, consumer electronics, white wastes are usually handled separately from other residential and commercial wastes.

Stationary container systems. Collection systems in which the containers used for the storage of wastes remain at the point of waste generation, except for occasional short trips to the collection vehicle.

Tipping floor. Unloading area for wastes delivered to an MRF, transfer station, or waste combustor.

Transfer. The act of transferring waste from the collection vehicle to larger transport vehicles.

Transfer station. A place or facility where wastes are transferred from smaller collection vehicles (e.g., compactor trucks) into larger transport vehicles (e.g., over the-road and off-road tractor trailers, railroad gondola cars, or barges) for movement to disposal areas, usually landfills. In some transfer operations, compaction or separation may be done at the station.

Transformation waste (see Waste transformation)

Transport. The Transport of solid wastes transferred from collection vehicles to a facility or disposal site for further processing or action.

Trash. Wastes that usually do not include food wastes but may include other organic materials, such as plant trimmings.

Treatment process sludges. Liquid and semisolid wastes, resulting from the treatment of domestic wastewater and industrial wastes.

Vadose zone. The zone between the surface of the ground and the permanent groundwater.

Virgin material. Any basic material for industrial processes that has not previously been used, for example, wood-pulp trees, iron ore, silica sand, crude oil, and bauuxite. See also Primary materials, Secondary material.

Volatile solid (VS). The portion of the organic material that can be released as a gas when organic material is burned in a muffle furnace at 5500C.

Volume reduction. The processing of wastes so as to decrease the amount of space they occupy. Compaction systems can reduce volume by 50 to 80 percent. Combustion can reduce waste volume by 90 percent.

Waste generation. The act or process of generating solid wastes.

Waste sources. Agricultural, residential, commercial, and industrial activities, open areas, and treatment plants where solid wastes are generated.

Waste stream. The waste output of an area, location, or facility.

Waste transformation. The transformation of waste materials involving a phase change (e.g., solid to gas). The most commonly used chemical and biological transformation processes are combustion and aerobic composting.

White goods. Large worn-out or broken household, commercial, and industrial appliances, such as stoves, refrigerators, dishwashers, and clothes washers and dryers.

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MAP 6

PLACES OF TOURIST INTEREST IN HARDWAR