SRI VIDYA COLLEGE OF ENGINEERING & TECHNOLOGY
VIRUDHUNAGAR
DEPARTMENT OF CIVIL ENGINEERING

QUESTION WITH ANSWERS

DEPARTMENT: CIVIL –IV
SEM:VII SUB.CODE/ NAME: EN6501 /Municipal Solid Waste Management.
UNIT 1- SOURCES AND TYPES PART - A (2marks)

1. **What is meant by solid waste?**
   Solid wastes are the organic and inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottles, kitchen refuse, paper, appliances, paint cans, batteries, etc., produced in a society, which do not generally carry any value to the first user(s).

2. **Examples of residential and commercial solid wastes.**
   Residential: This refers to wastes from dwellings, apartments, etc. and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.
   Commercial: This refers to wastes consisting of leftover food, glasses, metals, ashes, etc generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.
   Institutional: Consisting of schools and colleges (paper, plastics, glasses,etc.).
   Municipal: Consisting of wastes from demolition and construction activities (dust, building debris, etc.).
3. **What is called Waste generation?**
   Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. For example,wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste.
4. **List out the Biodegradable and non-biodegradable wastes:**
   Biodegradable wastes mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc.,

   generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds.
   Non-biodegradable wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals,

5. **What is called *Hazardous wastes?***
   Hazardous wastes are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. This is due to their

physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity.

6. **What is called Solid waste management (SWM).**

   Solid waste management (SWM) is associated with the control of waste generation, its storage, collection, transfer and transport, processing and disposal in a manner that is in accordance with the best principles of public health, economics, engineering, conservation, aesthetics, public attitude and other environmental considerations.

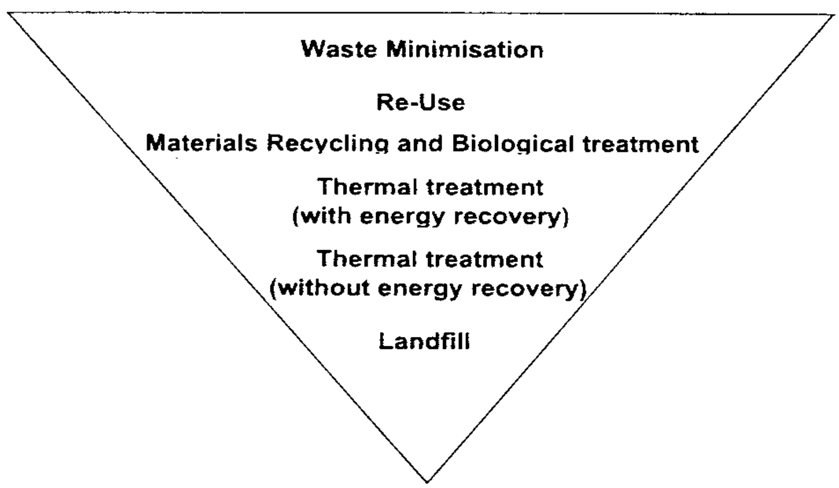
7. **List out the MSWM prinviples.**

   Protection of environmental health.
   Promotion of environmental quality.
   Supporting the efficiency and productivity of the economy.
   Generation of employment and income.

8. **What is called legislation?**

   This refers to the existence of local and state regulations concerning the use and disposal of specific materials and is an important factor that influences the composition and generation of certain types of wastes. The Indian legislation dealing with packing and beverage container materials is an example.In short elements that relate to waste generation include land use characteristics, population in age distribution, legislation, socio economic conditions, household and approximate number.

9. Draw Hierarchy of municipal solid waste management.



	SRI VIDYA COLLEGE OF ENGINEERING & TECHNOLOGY **VIRUDHUNAGAR** **DEPARTMENT OF CIVIL ENGINEERING**	

DEPARTMENT: CIVIL –IV SEM:VII SUB.CODE/ NAME: EN6501 /Municipal Solid Waste Management.

UNIT 1- SOURCES AND TYPES

PART - B (16 marks)

1.Explain the sources and types of solid wastes.

Source-based classification

Historically, the sources of solid wastes have been consistent, dependent on sectors and activities (Tchobanoglous, et al., 1977), and these include the following:

(i) **Residential:** This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) **Commercial:** This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

Management of Municipal Solid Waste 4

(iii) **Institutional:** This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) **Municipal:** This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc. (Note, however, in India *municipal* can typically subsume items at (i) to (iii) above).

(v) **Industrial:** This mainly consists of process wastes, ashes, demolition and construction wastes**,** hazardous wastes, etc., due to industrial activities.

(vi) **Agricultural:** This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

(vii) Open areas: this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

It is important to define the various types of solid wastes that are generated from various sources.

1. **Biodegradable and non-biodegradable wastes:**
   - ***Biodegradable wastes*** mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds.
   - ***Non-biodegradable*** **wastes** consist of inorganic and recyclable materials such as plastic, glass, cans, metals,

Type-based classification

Classification of wastes based on types, i.e., physical, chemical, and biological characteristics of wastes, is as follows (Phelps, et al., 1995):

(i) **Garbage:** This refers to animal and vegetable wastes resulting from the handling, sale, storage, preparation, cooking and serving of food. Garbage comprising these wastes contains putrescible (rotting) organic matter, which produces an obnoxious odour and attracts rats and other vermin. It,

therefore, requires special attention in storage, handling and disposal.
(ii) **Ashes and residues:** These are substances remaining from the burning of wood, coal, charcoal, coke and other combustible materials for cooking and heating in houses, institutions and small industrial establishments.

when produced in large quantities, as in power-generation plants and factories, these are classified as industrial wastes. Ashes consist of fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass. Since ashes and residues are almost entirely inorganic, they are valuable in landfills. (iii) **Combustible and non-combustible wastes:** These consist of wastes generated from households, institutions, commercial activities, etc., excluding food wastes and other highly putrescible material. Typically, while *combustible material* consists of paper, cardboard, textile, rubber, garden trimmings, etc., *non-combustible material* consists of such items as glass, crockery, tin and aluminium cans, ferrous and non-ferrous material and dirt.

(iv) **Bulky wastes:** These include large household appliances such as refrigerators, washing machines, furniture, crates, vehicle parts, tyres, wood, trees and branches. Since these household wastes cannot be accommodated in normal storage containers, they require a special collection mechanism.

(v) **Street wastes:** These refer to wastes that are collected from streets, walkways, alleys, parks and vacant plots, and include paper, cardboard, plastics, dirt, leaves and other vegetable matter. Littering in public places is indeed a widespread and acute problem in many countries including India, and a solid waste management system must address this menace appropriately.

(vi) **Biodegradable and non-biodegradable wastes:** *Biodegradable wastes* mainly refer to substances consisting of organic matter such as leftover food, vegetable and fruit peels, paper, textile, wood, etc., generated from various household and industrial activities. Because of the action of micro-organisms, these wastes are degraded from complex to simpler compounds. *Non-biodegradable* wastes consist of inorganic and recyclable materials such as plastic, glass, cans, metals, etc. Table 1.1 below shows a comparison of biodegradable and non-biodegradable wastes with their degeneration time, i.e., the time required to break from a complex to a simple biological form

(vii) **Dead animals:** With regard to municipal wastes, dead animals are those that die naturally or are accidentally killed on the road. Note that this category does not include carcasses and animal parts from slaughter-houses, which are regarded as industrial wastes. Dead animals are divided into two groups – large and small. Among the large animals are horses, cows, goats, sheep, pigs, etc., and among the small ones are dogs, cats, rabbits, rats, etc. The reason for this differentiation is that large animals require special equipment for lifting and handling when they are removed. If not collected promptly, dead animals pose a threat to public health since they attract flies and other vermin as they decay. Their presence in public places is particularly offensive from the aesthetic point of view as well.

(viii) **Abandoned vehicles:** This category includes automobiles, trucks and trailers that are abandoned on streets and other public places. However, abandoned vehicles have significant scrap value for their metal, and their value to collectors is highly variable.

(ix) **Construction and demolition wastes:** These are wastes generated as a result of construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. They consist mainly of earth, stones, concrete, bricks, lumber, roofing and plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream.

(x) **Farm wastes:** These wastes result from diverse agricultural activities such as planting, harvesting, production of milk, rearing of animals for slaughter and the operation of feedlots. In many areas, the disposal of animal waste has become a critical problem, especially from feedlots, poultry farms and dairies.

(xi) **Hazardous wastes:** *Hazardous wastes* are those defined as wastes of industrial, institutional or consumer origin that are potentially dangerous either immediately or over a period of time to human beings and the environment. This is due to their physical, chemical and biological or radioactive characteristics like ignitability, corrosivity, reactivity and toxicity. Note that in some cases, the active agents may be liquid or gaseous hazardous wastes. These are, nevertheless, classified as solid wastes as they are confined in solid containers. Typical examples of hazardous wastes are empty containers of solvents, paints and pesticides, which are frequently mixed with municipal wastes and become part

of the urban waste stream. Certain hazardous wastes may cause explosions in incinerators and fires at landfill sites. Others such as pathological wastes from hospitals and radioactive wastes also require special handling. Effective management practices should ensure that hazardous wastes are stored, collected, transported and disposed of separately, preferably after suitable treatment to render them harmless.

xii) **Sewage wastes:** The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages. The inorganic fraction of raw sewage such as grit and eggshells is separated at the preliminary stage of treatment, as it may entrain putrescible organic matter with pathogens and must be buried without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but is invariably uneconomical. Solid sludge, therefore, enters the stream of municipal wastes, unless special arrangements are made for its disposal.

Category	Type of waste	Approximate time taken to degenerate
Biodegradable	Organic waste such as vegetable and fruit peels, leftover foodstuff, etc.	A week or two.
	Paper	10–30 days
	Cotton cloth	2–5 months
	Woollen items	1 year
	Wood	10–15 years
Non-biodegradable	Tin, aluminium, and other metal items such as cans	100–500 years
	Plastic bags	One million years
	Glass bottles	Undetermined

	Type	Description	Sources
Solid Wastes	Garbage	Food waste: wastes from the preparation, cooking and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meat.	Households, institutions and commercial concerns such as hotels, stores, restaurants, markets, etc.
	Combustible and non–combustible	Combustible (primary organic) paper, cardboard, cartons, wood, boxes, plastic, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings, etc.	
		Non-combustible (primary inorganic) metals, tin, cans, glass bottles, crockery, stones, etc.	
	Ashes	Residue from fires used for cooking and for heating building cinders	
	Bulky wastes	Large auto parts, tyres, stoves, refrigerators other large appliances, furniture, large crates, trees, branches, stumps, etc.	Streets, sidewalks, alleys, vacant lots, etc.
	Street wastes	Street sweepings, dirt, leaves, etc.	
	Dead animals	Dogs, cats, rats, donkeys, etc.	
	Abandoned vehicles	Automobiles and spare parts	
	Construction and demolition wastes	Roofing, and sheathing scraps, rubble, broken concrete, plaster, conduit pipe, wire, insulation, etc.	Construction and demolition sites.
	Industrial wastes	Solid wastes resulting from industry processes and manufacturing operations, such as, food processing wastes, boiler house cinders, wood, plastic and metal scraps, shavings, etc	Factories, power plants, etc.
	Hazardous wastes	Pathological wastes, explosives, radioactive materials, etc.	Households, hospitals, institutions, stores, industry, etc.
	Animal and agricultural wastes	Manure, crop residues, etc.	Livestock, farms, feedlots and agriculture
	Sewage treatment residue	Coarse screening grit, septic tank sludge, dewatered sludge.	Sewage treatment plants and septic tanks.

2.Explain the SOLID WASTE CHARACTERISTICS.
SOLID WASTE CHARACTERISTICS

In order to identify the exact characteristics of municipal wastes, it is necessary that we analyse them using physical and chemical parameters (Phelps, et al., 1995), which we will discuss in Subsections 2.3.1 and 2.3.2, respectively.

2.3.1 Physical characteristics Information and data on the physical characteristics of solid wastes are important for the selection and operation of equipment and for the analysis and design of disposal facilities. The required information and data include the following:

(i) **Density:** Density of waste, i.e., its mass per unit volume (kg/m3), is a critical factor in the design of a SWM system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc. To explain, an efficient operation of a landfill demands compaction of wastes to optimum density. Any normal compaction equipment can achieve reduction in volume of wastes by 75%, which increases an initial density of
100 kg/m3 to 400 kg/m3. In other words, a waste collection vehicle can haul four times the weight of waste in its compacted state than when it is uncompacted. A high initial density of waste precludes the achievement of a high compaction ratio and the compaction ratio achieved is no greater than 1.5:1. Significant changes in density occur spontaneously as the waste moves from source to disposal, due to scavenging, handling, wetting and drying by the weather, vibration in the collection vehicle and decomposition. Note that:

- the effect of increasing the moisture content of the waste is detrimental in the sense that dry density decreases at higher moisture levels;
- soil-cover plays an important role in containing the waste;
- there is an upper limit to the density, and the conservative estimate of in-place density for waste in a sanitary landfill is about 600 kg/m3.

(ii) **Moisture content:** Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total weight of the wet waste. Moisture increases the weight of solid wastes, and thereby, the cost of collection and transport. In addition, moisture content is a critical determinant in the economic feasibility of waste treatment by incineration, because wet waste consumes energy for evaporation of water and in raising the temperature of water vapour. In the main, wastes should be insulated from rainfall or other extraneous water. We can calculate the moisture percentage, using the formula given below:

$$\textbf{Moisture content (\%)} = \frac{\text{Wet weight - Dry weight}}{\text{Wet weight}} \times 100$$

A typical range of moisture content is 20 to 40%, representing the extremes of wastes in an arid climate and in the wet season of a region of high precipitation. However, values greater than 40% are not uncommon.

(iii) **Size:** Measurement of size distribution of particles in waste stream is important because of its significance in the design of mechanical separators and shredders.

Generally, the results of size distribution analysis are expressed in the manner used for soil particle analysis. That is to say, they are expressed as a plot of particle size (mm) against percentage, less than a given value. The physical properties that are essential to analyse wastes disposed at landfills are:

I. Field capacity: The field capacity of MSW is the total amount of moisture which can be retained in a waste sample subject to gravitational pull. It is a critical measure because water in excess of field capacity will form leachate, and leachate can be a major problem in landfills. Field capacity varies with the degree of applied pressure and the state of decomposition of the wastes.

II. Permeability of compacted wastes: The hydraulic conductivity of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill. Permeability depends on the other properties of the solid material include pore size distribution, surface area and porosity.

Porosity: It represents the amount of voids per unit overall volume of material. The porosity of MSW varies typically from 0.40 to 0.67 depending on the compaction and composition of the waste.

Porosity of solid waste $n= e/ (1+e)$,
Where e is void ratio of solid waste

III. Compressibility of MSW: Degree of physical changes of the suspended solids or filter cake when subjected to pressure.

$\Delta HT = \Delta Hi + \Delta Hc + \Delta H\alpha$ [ΔHT= total settlement;
ΔHi=immediate settlement;
ΔHc = consolidation settlement;
$\Delta H\alpha$ = secondary compression or creep.]
$C'\alpha = \Delta H/ [H0 \times (\log (t2/t1))] = C\alpha/ (1+e0)$
[$C\alpha$, $C'\alpha$ = Secondary compression index and Modified secondary Compression index; and t1, t2= Starting and ending time of secondary settlement respectively.]

3.Explain the Public health effects in MSWM.

Public health effect The volume of waste is increasing rapidly as a result of increasing population and improving economic conditions in various localities. This increased volume of wastes is posing serious problems due to insufficient workforce and other constraints in disposing of it properly. What are the consequences of improper management and handling of wastes? Consider the following:

(i) **Disease vectors and pathways:** Wastes dumped indiscriminately provide the food and environment for thriving populations of vermin, which are the agents of various diseases. The pathways of pathogen transmission from wastes to humans are mostly indirect through insects – flies, mosquitoes and roaches and animals – rodents and pigs. Diseases become a public health problem when they are present in the human and animal population of surrounding communities, or if a carrier transmits the etiological agent from host to receptor.

(ii) **Flies:** Most common in this category is the housefly, which transmits typhoid, salmonellosis, gastro-enteritis and dysentery. Flies have a flight range of about 10 km, and therefore, they are able to spread their influence over a relatively wide area. The four stages in their life-cycle are egg, larva, pupa and adult. Eggs are deposited in the warm, moist environment of decomposing food wastes. When they hatch, the larvae feed on the organic material, until certain maturity is reached, at which time they migrate from the waste to the soil of other dry loose material before being transformed into pupae. The pupae are inactive until the adult-fly emerges. The migration of larvae within 4 to 10 days provides the clue to an effective control measure, necessitating the removal of waste before migration of larvae. Consequently, in warm weather, municipal waste should be collected twice weekly for effective control. In addition, the quality of household and commercial storage containers is very significant. The guiding principle here is to restrict access to flies. Clearly, the use of suitable storage containers and general cleanliness at their location, as well as frequent collection of wastes, greatly reduces the population of flies. Control is also necessary at transfer stations, composting facilities and disposal sites to prevent them from becoming breeding grounds for flies. Covering solid wastes with a layer of earth at landfill sites at the end of every day arrests the problem of fly breeding at the final stage.

(iii) **Mosquitoes:** They transmit diseases such as malaria, filaria and dengue fever. Since they breed in stagnant water, control measures should centre on the elimination of breeding places such as tins, cans, tyres, etc. Proper sanitary practices and general cleanliness in the community help eliminate the mosquito problems caused by the mismanagement of solid waste.

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(iv) **Roaches:** These cause infection by physical contact and can transmit typhoid, cholera and amoebiasis. The problems of roaches are associated with the poor storage of solid waste.

(v) **Rodents:** Rodents (rats) proliferate in uncontrolled deposits of solid wastes, which provide a source of food as well as shelter. They are responsible for the spread of diseases such as plague, murine typhus, leptospirosis, histoplasmosis, rat bite fever, dalmonelosis, trichinosis, etc. The fleas, which rats carry, also cause many diseases. This problem is associated not only with open dumping but also poor sanitation.

(vi) **Occupational hazards:** Workers handling wastes are at risk of accidents related to the nature of material and lack of safety precautions. The sharp edges of glass and metal and poorly constructed storage containers may inflict injuries to workers. It is, therefore, necessary for waste handlers to wear gloves, masks and be vaccinated. The infections associated with waste handling, include:

- skin and blood infections resulting from direct contact with waste and from infected wounds;
- eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations;
- diseases that result from the bites of animals feeding on the waste;

- intestinal infections that are transmitted by flies feeding on the waste;
- chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds.

In addition, the accidents associated with waste handling include:

- bone and muscle disorders resulting from the handling of heavy containers and the loading heights of vehicles;
- infecting wounds resulting from contact with sharp objects;
- reduced visibility, due to dust along the access routes, creates greater risk of accidents;
- poisoning and chemical burns resulting from contact with small amounts of hazardous chemical wastes mixed with general wastes such as pesticides, cleaning solutions and solvents in households and commercial establishments;
- burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites;
- serious health hazards, particularly for children, due to careless dumping of lead-acid, nickel-cadmium and mercuric oxide batteries.

(vii) **Animals:** Apart from rodents, some animals (e.g., dogs, cats, pigs, etc.) also act as carriers of disease. For example, pigs are involved in the spread of diseases like trichinosis, cysticerosis and toxoplasmosis, which are transmitted through infected pork, eaten either in raw state or improperly cooked. Solid wastes, when fed to pigs, should
be properly treated (cooked at 100C for at least 50 minutes with suitable equipment).

4.Explain the CASE STUDY: STATUS OF WASTE GENERATION IN ANY INDIAN CITY
CASE STUDY: STATUS OF WASTE GENERATION IN BANGALORE

SWM in urban areas has interface with all aspects of life and government administration (Areivala, 1971). And, through this case study, we intend to share with you some practical aspects of SWM, from the disposal of building debris to
organic, putrescible, and bio-medical wastes and their possible recycling potential. For details, see http://stratema.sigis.net/cupum/pdf/E1.pdf. Bangalore, also known as the Garden City, is one of the fastest growing metropolitan cities in South India. It is the state capital of Karnataka and the sixth largest city in India. Topographically, Bangalore is located in the south deccan and physically, has grown on watershed running through the middle of the Mysore Plateau from west to east which serves as the main water parting of the state at an average elevation of 900 meters above sea level. The city gets moderate rainfall of around 900 mm largely between June and October. On account of its elevation, Bangalore is bestowed with salubrious and equable climate comparable to those of temperate regions. The city covers the local planning area of 500 sq. kms. Out of this, 226.16 sq. kms are developed at present. In 1991, its population was 4.16
million and has grown over 6 million, as per recent projected population estimates. Besides, the city has a floating population of over 0.5 million. It is a fast growing city beset with the usual problems of inadequate waste management, due to constraints such as lack of finance and other resources, deficiencies in equipment and workforce and paucity of space (for waste disposal). The Bangalore Mahanagara Palike (BMP), the

erstwhile Bangalore City Corporation (BCC), is concerned with the prime areas of public health, solid waste management including health care waste and sanitation, education, horticulture, etc. Working with non-governmental and voluntary organisations of all stakeholders in a participatory approach, BMP is striving to implement suggestions towards an improved SWM. SWM is a vital function of the Health Department, supported by the Engineering Department of BMP and the health officer heads the SWM wing. In the present context, SWM in BMP essentially means the cleaning of streets, emptying dustbins, transportation of wastes to city outskirts and burning them in open areas for their disposal (Attarwalla, 1993, Gotoh, 1989, Development, 1998, Ogawa, 1989, and Vagale, 1997).

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The waste generation and composition details of Bangalore are as follows: (i) **Waste generation:** Bangalore produces over 2500 tonnes of solid waste per day and the Municipal Corporation has miserably inadequate infrastructure in managing the disposal of solid wastes generated. It is estimated that the per capita generation of solid waste works out to 0.59 kg/day. The sources of waste generation and the amount generated at each source are given in Table 2.6.

Table 2.6 Different Sources of Solid Waste Generation in Bangalore

Sl No.	**Source**	**Quantity (in MT/day)**
1	Households	
2	Shops, Establishments, Institutions, etc.	600
3	Markets	600
4	Others	300
5	TOTAL	2500

Source: Department of SWM, Bangalore Mahanagara Palike, Bangalore

(ii) **Waste composition:** The composition of wastes in Bangalore has wide variations in the proportion of contents. It varies from area to area, depending upon the socio- economic conditions and the population density. The composition of the total wastes generated in Bangalore city is given in Table 2.7.

Table 2.7 Composition of Solid Waste in Bangalore

Sl No.	**Type of Waste**	**Composition (in percentage)**
1	[illegible]	75.2
2	Dust and ash	12
3	Textiles	3.1
4	Paper	1.5
5	Plastic, leather and rubber	0.9
6	Glass	0.2
7	Metals	0.1
8	Earth and building debris and others	0.7

Source: Department of SWM, Bangalore Mahanagara Palike, Bangalore In Bangalore, there are 401 slum pockets identified which come under the jurisdiction of three different authorities, viz., Bangalore City Corporation - 64 slums, Bangalore Development Authority – 64 slums, and Karnataka Slum Clearance Board – 273 slums. Fifteen percent of the city's population lives in these slums (Comprehensive Development Plan (Revised) Bangalore Report, 1995, p. 25). The slum locations are generally found to be least desirable from the point of view of habitation – being low lying areas, tank beds, quarry pits, near railway lines and cemeteries. The authorities have been unable to clear the garbage from most of the slums mainly due to the slum dwellers' practice of throwing their wastes into drains, and only part of the waste generated is available for collection. There are 12 large vegetable and fruit markets other than a number of small groups of pavement vegetable vendors. Approximately, these markets are producing more than 150 tonnes of wastes daily. In addition to this, large quantities of wastes get generated from slaughterhouses, food packing industries and cold storage facilities.

5.Explain the Improper handling of wastes.

Improper handling of wastes

Some of the adverse health and environmental effects, due to the improper handling of wastes are:

(i) **Health effects**: Wastes dumped indiscriminately provide the food and environment for breeding of various vectors, e.g., flies (salmonellosis, dysentry, etc.), mosquitoes and roaches (malaria, dengue fever, typhoid, cholera, amoebiasis, etc.) and animals, e.g., rodents and pigs (trichinosis, cysticerosis, etc.).

(ii) **Environmental effects**: Inadequate and improper waste management has serious environmental effects. These include air, water, land, visual, noise and odour pollution, and explosion hazards.

I reside in ward no. 89 of Bangalore, Karnataka, India where sufficient precaution is not practised, while handling municipal solid wastes. Based on a general observation, the four effects are the following:

- Due to open dumping, mosquitoes thrive in our locality, which may cause diseases like malaria or dengue fever.
- Rodents, notably rats proliferate in uncontrolled deposits of solid waste, which provide them with a convenient source of food and shelter.
- There is a risk of injury during handling of wastes, as workers are not provided with safety materials, e.g., gloves.
- The aesthetic sensibility (i.e., visual pollution) of concerned residents is offended by the unsightliness of piles of wastes.

6. Explain the Principle of solid waste management.

Principle of solid waste management

A SWM system refers to a combination of various functional elements associated with the management of solid wastes. The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs,
while preserving public health and ensuring little or minimal adverse impact on the environment. The functional elements that constitute the system are:
(i) **Waste generation:** Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. The source
of waste generation, as we touched upon earlier in Section 1.1, determines quantity, composition and waste characteristics (see Unit 2 for details). For example, wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste.
(ii) **Waste storage:** Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. The heterogeneous wastes generated in residential areas must be removed within 8 days due to shortage of storage space and presence of biodegradable material. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bins (for institutions and commercial areas or servicing depots), etc. Obviously, these vary greatly in size, form and material. We shall discuss waste storage in detail in Unit 3.
(iii) **Waste collection:** This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station (i.e., intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated), a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.
Note that the solution to the problem of hauling is complicated. For instance, vehicles used for long distance hauling may not be suitable or particularly economic for house-to-house collection. Every SWM system, therefore, requires
an individual solution to its waste collection problem, and we will explain this in Unit 3.
(iv) **Transfer and transport:** This functional element involves:
 the transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations;
 the subsequent transport of the wastes, usually over long distances, to disposal sites.

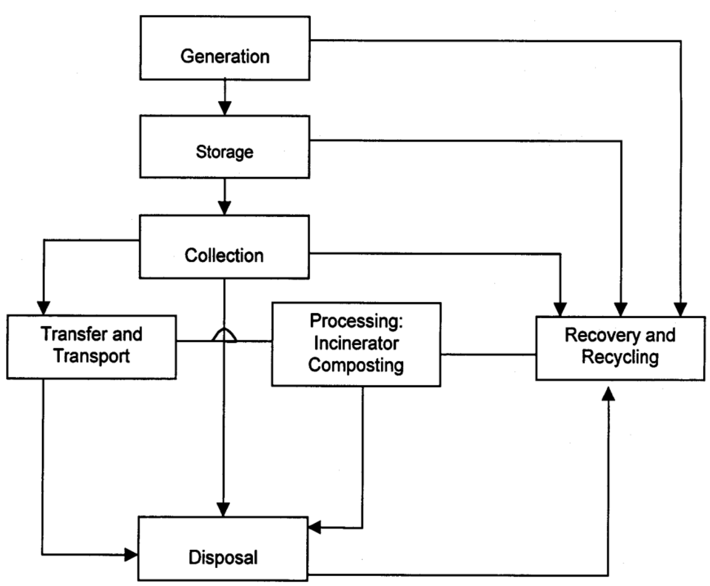
The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements. We will discuss these in Unit 3.
(v) **Processing:** Processing is required to alter the physical and chemical
characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, manual separation

of waste components, incineration and composting. We will discuss the various functions involved in waste processing in detail in Unit 5.

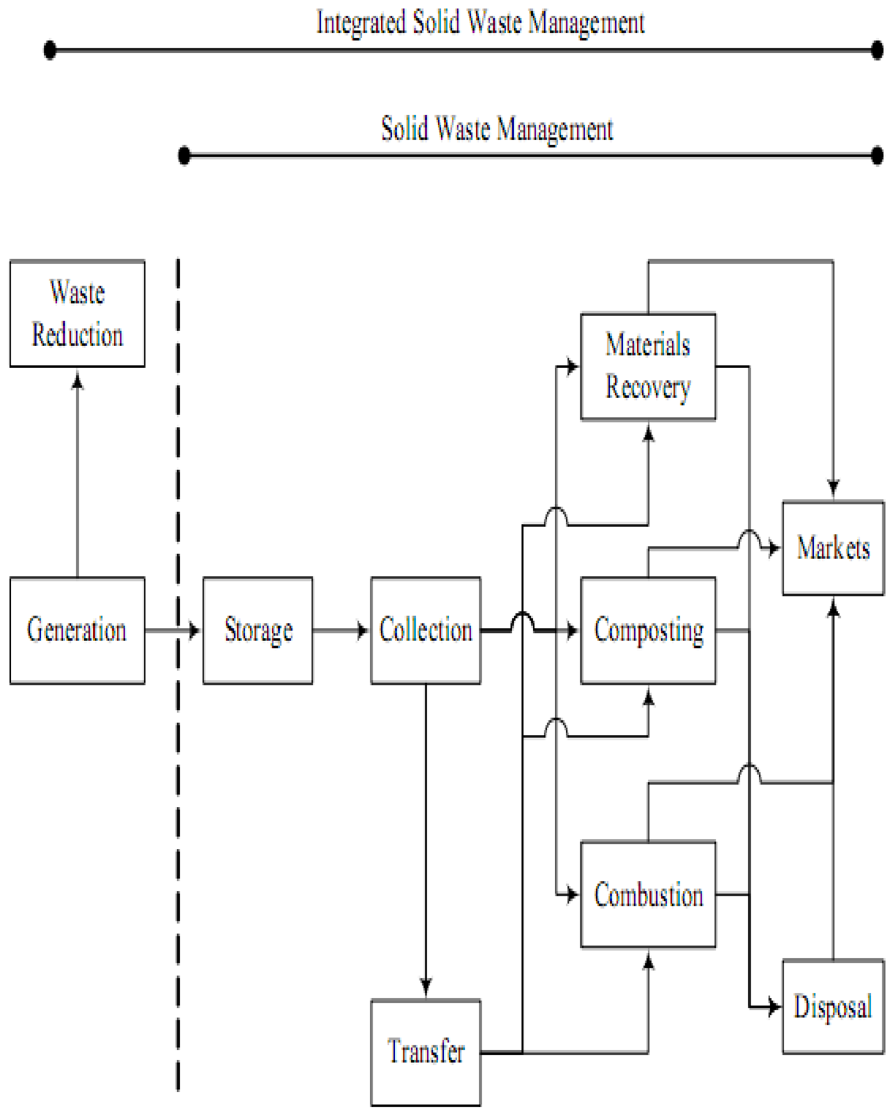
(vi) **Recovery and recycling:** This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass. The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value. We will discuss the various aspects of recovery and recycling, respectively, in Units 6 and 7.

(vii) **Waste disposal:** Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment plants, incinerator residues, composts or other substances that have no further use to the society. Thus, land use planning becomes a primary determinant in the selection, design and operation of landfill operations. A modern sanitary landfill is a method of disposing solid waste without creating a nuisance and hazard to public health. Generally, engineering principles are followed to confine the wastes to the smallest possible area, reduce them to the lowest particle volume by compaction at the site and cover them after each day's operation to reduce exposure to vermin. One of the most important functional elements of SWM, therefore, relates to the final use of the reclaimed land.

In Figure 1.1 below, we show you a typical SWM system with its functional elements and linkages:



Integrated Solid Waste Management



7.Explain the PUBLIC EDUCATION AND INVOLVEMENT In MSWM.

PUBLIC EDUCATION AND INVOLVEMENT

Developing integrated solutions for waste management problems requires public involvement. To operate a waste management programme economically and efficiently, significant cooperation is expected from waste generators, regardless of the strategies chosen – buying products in bulk, separating recyclables from non-recyclables, dropping off garden trimmings at a compost site, removing batteries from materials sent to a waste-to-energy facility, or using designated containers for collecting materials. To sustain a long-term programme support, the public needs to know clearly the purpose and necessity of desired behaviours.

Involving people in the waste management requires a significant educational effort by the community. Ineffective or half-hearted education programmes may confuse the public, reduce public confidence or elicit hostility towards the programme. Successful education programmes must be consistent and ongoing. Public education stimulates interest in how waste management decisions are made, and when citizens become interested in their community's waste management programmes, they frequently demand to be involved in the decision-making process. Communities should anticipate such interest and develop procedures for involving the public. When the public is involved in programme design, it helps ensure the smooth running of the programmes (EPA, 1989 and 1995).

We now discuss some aspects of public education and involvement in Subsections 10.1

8. Planning a public education programme

Successful public education plans are the result of careful planning. By developing a realistic education plan, you can assess the situation and know where best to direct their efforts and resources. This will benefit from taking advantage of all opportunities to work with the community. The process of Planning a public education programme is explained below.

Planning a public education programme:

Awareness

At the awareness stage, people encounter a new idea or a new way of doing things. At this stage, they do not possess enough information to decide whether a change in behaviour is a good idea or whether they should be concerned. The goal of the awareness stage is to let people know that a different way of handling waste may be preferable to the historical way and that good reasons for considering a change in their waste management practices do exist. A variety of methods can increase awareness, in which low-cost methods include news articles and public service announcements, or shows on radio and television and high cost efforts include television commercials or billboards. Over the long term, education in schools is the best way of raising awareness; the school curriculum must include the concepts of source reduction, recycling composting and other waste management techniques. Besides educating the next generation of citizens, school programmes indirectly help make parents aware of waste issues because children frequently take home information they have learned and discuss it with their parents.

Interest

In the second stage, individuals who are now aware of waste management issues seek additional information. They may seek one-to-one exchanges with waste management professionals, educators, and so on or they may seek information about how they are involved in implementing a waste management initiative or an effective public policy. Making changes in required local waste management practices, such as mandatory recycling or garden trimmings disposal bans, will clearly stimulate interest (sometimes even in the form of political opposition!). At this stage, programme developers may need a variety of methods to explain the programme. Making public speeches, offering tours of waste management facilities, creating exhibits for fairs and preparing written material such as newsletters can help stimulate public interest in the programme.

Evaluation

At the evaluation stage, individuals decide whether to go along with the programme. Even if the law requires specific behaviour, achieving voluntary compliance is easier administratively and politically than strong enforcement. An easily understandable and convenient programme will have the best chance of success. Research has shown that for even well promoted programmes, initial participation is about 50%. Initial high participation rates, therefore, should not be expected. Even for mandatory programmes, convenience is a major factor in determining participation. For example, the convenience of curbside pickup normally makes participation in waste management programmes higher than for drop-off programmes. As a result, some communities only provide drop-off service for garden trimmings, so that it becomes more convenient not to collect grass clippings or home compost. A combined curbside and drop-off programme may be the most convenient. To make this happen, education should stress the role of individuals in the programme, their contribution to its success and the most convenient level of participation. *Municipal Solid Waste Management 466*

Trial

By the fourth stage, individuals would have decided to participate in the new activity. This is a crucial step for every programme. For example, if individuals try garden composting or a volume-based system and encounter difficulty, they may choose not to adopt the desired conduct, and the programme could lose political and public support. By this stage in the educational programme, therefore, everyone should have the information, describing exactly what they are expected to do. The community programme must then provide the promised service in a highly reliable fashion. At the trial stage of a volunteer programme, a pilot project can also help stimulate participation. Programme organisers should assure citizens that the pilot project" s goal is to evaluate various strategies, respond to public feedback and make any changes required to improve programme efficiency and reliability. Citizens may be more willing to try a project, if they know whether the project is short-term and that any concerns they may have will be taken into account in developing a long-term effort. During the trial stage, public hearings may be helpful by giving citizens an opportunity to voice their opinions about the project.

Adoption

If the education programme has been well planned and implemented, public support and participation should grow. Educational efforts at this fifth stage focus on providing citizens with positive feedback concerning programme effectiveness. A newsletter or other regular informational mailing can help inform citizens about the programme‟ s progress and any programme changes. Community meetings can serve to reward and reinforce good behaviour and answer questions. Local officials should be informed of programme participation rates to generate political support for programme budgets and personnel needs.

Maintenance

At the sixth stage, the programme progresses smoothly. The use of a variety of intrinsic and extrinsic incentives will maintain and increase participation. Intrinsic incentives are largely information in nature, designed to induce citizens to perform the desired conduct and to provide a personal sense of well-being and satisfaction. Some studies, for example, have shown that the ideals of frugality, resource conservation and environmental protection over the long run were strong intrinsic motivators for those participating in recycling and reuse programmes. Extrinsic incentives are tangible and direct rewards for performing the desired conduct, such as reduced fees or monetary payments. For example, the smaller the waste volume generated, the lesser the generator (of wastes) must pay for waste management. A maintenance programme may employ both the types of incentives, while continuing with basic education.

10.2 Planning public involvement

Participation of local residents should begin at the very early stage of the programme development. For example, it should begin even at the stage of making decisions regarding the overall waste management strategy that best meets the community‟ s economic and environmental needs. The strategy should consider source reduction and other options in addition to the facility being proposed. The public must also accept responsibility for its role in implementing sound and cost effective waste management solutions.

Developing a written plan for seeking public involvement is important. Written procedures help insure the inclusion of all important interests and legal requirements. The plan will show involved citizens and groups at which points in the process they can express opinions and how to be most effective in communicating their views. In fact, a written, publicly available plan lends credibility to the programme. The "issue evolution-educational intervention" (IEEI) model provides public involvement throughout the decision-making process (EPA, 1989 and 1995). This model comprises an eight-stage process for developing and implementing public policy. The IEEI process ensures that the public will have a meaningful voice in deciding how best to manage solid waste. The process is not simple, and requires a commitment from the community for time and resources. Each of these stages is described below

(i) **Concern:** In the first stage, an event puts waste management on the public agenda. The public begins to ask questions. At this stage, a procedure for providing accurate and reliable information to the public is important. Eliminating misconceptions and establishing a firm educational base for public discussion is the key. Educational institutions, offices, governmental associations and regulatory agencies can provide information. Education programmes should target local officials, as well as the public. Showing concern and a willingness to take proper action is most important. A focus group can help define important public issues, and a community service organisation can provide a forum for discussion.

(ii) **Involvement:** As discussion of the issue begins, regulatory officials, persons from neighbouring communities, local waste management experts, environmental and business groups and others should be encouraged to participate. Bringing representatives of interest groups together and providing a forum for communication is a valuable activity. Cultural diversity is another consideration when seeking input from the broadest possible spectrum of the community.

(iii) **Issue resolution:** Interest groups should make clear their points of agreement and disagreement. The various groups should then attempt to understand and resolve points of conflict. Determining what people can agree on is also important. All parties need to understand the motivation and circumstances of the other community interests in the process.

(iv) **Alternatives:** The participants should develop a list of available alternatives and each alternative should have a list of potential sites for facilities. At this stage, participants should use the same criteria to analyse comparative economics, environmental impacts and other aspects of each alternative. Each interest group should scrutinise carefully the analyses prepared by others. Results of analyses of various alternatives should be communicated to local officials and input sought from the public and others. *Unit 10: Integrated Waste Management (IWM) 469*

(v) **Consequences:** At this stage, involved parties should determine and compare the economic and environmental effects of each alternative. They should also evaluate consequences in light of community resources and goals, and the public must understand the results of choosing one alternative over another. All involved interest groups should acknowledge the benefits and costs associated with each alternative.

(vi) **Choice:** The deciding body must decide, at this stage, an alternative or a combination of alternatives chosen for implementation. In addition to publicising the chosen alternative or alternatives, decision-makers should clearly communicate the reasons behind each choice by explaining the necessary trade-offs, the efforts made to consider the interests of each affected group and the anticipated impact of the chosen alternative or alternatives on the community. This will help develop a broad community consensus, enabling the community to better withstand legal and political challenges. (We should not, however, expect a 100% support from all the interest groups involved to the chosen alternative or alternatives!)

(vii) **Implementation:** At this stage, the decision-makers should describe the steps necessary to implement the chosen strategy. They should also try to mitigate potential adverse impacts, which the chosen alternative or alternatives may have on relevant interest groups.
(viii) **Evaluation:** The community should continually evaluate the model and solicit input from affected groups. The impact of decisions should be communicated routinely to the public and to the local officials. Ongoing evaluation helps provide an information base for making future waste management decisions, and the existing programmes will continually improve, if they respond to changing conditions and public input.
After learning ISWM and role of LCA in ISWM let us now consider policy on IMSW management by Government of Karnataka state as a final section of the unit.

10.4 Policy on Integrated municipal solid waste management Karnataka
The policy of IMSW by the Government of Karnataka aimed at catalysing modernisation of MSW management services uniformly in the state and includes
Specific plans to improve seven components including

- Segregation Storage
- at source Primary
- collection Secondary
- storage Secondary
- transport Treatment
- Landfill

Minimisation of human contact with waste and increase in its mechanical handling.

Specific normative standards are followed. Standard tool kits for build-operate-transfer (BOT) and operation & maintenance (O&M) practices are followed; for all type and size of local bodies manuals on specifications of equipments, vehicles, guidelines on treatment and landfill of wastes are issued. This manual as well includes approach for information, communication and education.

Specifications for type of vehicles that can be used for primary collection such as auto tippers, tricycle and push cart are mentioned. And for secondary storage such as variable capacity metal containers and others advisable are highlighted.

Recommendations for class I and non class I cities are mentioned for secondary transport using hydraulically operated systems. For example for class I twin container and dumper placer can be used and for non class I single container and tractor placer can be used.

Recommendations on treatment and disposal facilities for various types of towns are also given based on MSW Rules 2000. Suggestions given for class I cities are to have both treatment and sanitary landfill where as for Non class I to have only engineering landfills.