

# UNIT 10

## SOLID AND LIQUID WASTE

### Structure

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### 10.1 INTRODUCTION

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You have studied about the pollution as a whole and air pollution in particular in the previous Units 9 and 10, respectively. This unit will focus on wastes, their types, impacts, and management. Wastes are one of the major environmental problems. Wastes, in the form of solid and liquid, are creating lots of problems for the local economy in general and the world in particular. Section 10.2 presents you the types of wastes and its classification. Wastes create a huge burden on the global environment. The huge generation of waste leads to the origin of several other environmental issues at the macro level and it affects the overall development of regions. They are of various types and their management is the need of the hour. We have explained the effects of solid and liquid wastes on public health and environment in Section 10.3 followed by the management of wastes in Section 10.4.

## Expected Learning Outcomes

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After completing the study of this unit, you should be able to:

- ❖ explain the different types and classification of wastes;
- ❖ describe major effects of solid and liquid wastes; and
- ❖ elucidate the different methods of waste management.

## 10.2 TYPES AND CLASSIFICATION OF WASTES

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Since the starting of the industrial revolution particularly, the human beings have been generating wastes. In the present time, in response to the increasing production and consumption patterns, societies are producing a huge amount of wastes. However, we know that nature can assimilate them, but we are producing more wastes than the assimilation rate of nature. Therefore, we are facing this environmental degradation challenge in a big way in the 21<sup>st</sup> century.

In most simplified terms, **waste** means any materialistic item which is no more useful. Waste is anything that is not required by an individual because of single or many other factors. Further, it can be stated that waste is anything that remains at the end of a process and does not have any utility and functionality for a user. Wastes are normally found in solid and liquid state which are generated from various human and animal activities and are regarded as useless or unwanted. Wastes have been defined in various ways. Gemmell et al. (1984) defined wastes as “*unwanted or undesirable products of life*”. Also, they range in character from organic materials like human and animal excreta to metallic, plastic, and chemical by-products of manufacturing industry. Bilitewski et al. (1997) in their paper defined waste subjectively and objectively. Subjectively, ‘*wastes are portable objects that have been abandoned by the owner*’, while objectively, waste defined as ‘*orderly disposal of garbage as required for the protection of public health and, in particular, of the environment*’. Wastes are seen as a problem in a particular area for the local people and their surrounding environment. Most of the time, wastes are managed until the time, they are within the limit, but when this limit exceeds the capacity, the environmental quality degrades and management efforts are initiated to tackle the problem.

All wastes are not useless, with the advancement of technologies it has become possible to recycle/reuse the waste to manufacture other useful products. Sometimes waste to one user may be a useful material for someone else also. For example, glass materials, paper cardboard and metals can be reused; and peels of fruits, garden wastes, etc. can also be used to make compost (organic manure). Actually, in the present time, nothing is waste because most of the things can be reused and recycled.

### 10.2.1 Types of Wastes

There are three types of wastes based on their state in nature. They are found in solid, liquid, and in a gaseous state.

**Solid wastes** are non-soluble wastes or solid portion of rejected materials from various sectors like plastics, glass-made items, food wastes, paper, wood, metals and mining residue, etc. Most of the solid wastes are not recyclable and take long time to get degraded.

**Liquid wastes** are liquid portions of the wastes which include urban wastewater, sewage, effluents from industries and landfill sites, agriculture runoff and leaching of agricultural chemicals, etc. Liquid wastes are generally transported by using containers or through pipes. The excess amounts of sewage discharged into a river/water body can alter the fragile ecosystem resulting the death of aquatic species for example fish.

**Gaseous wastes** include wastes in gaseous form produced by the result of various human activities from manufacturing industries, chemical factories, etc. The gases comprise of methane ( $\text{CH}_4$ ), carbon dioxide ( $\text{CO}_2$ ), chlorofluorocarbons (CFCs) are also responsible for environmental problems like pollution, climate change and so on. We will study only solid and liquid wastes in this Unit.

### 10.2.2 Classification of Wastes

Wastes can be categorized mainly into two classes based on their source of generation and type of materials. Let us discuss one by one.

#### 1. Classification based on Source

The most common types of wastes which are originated at source particularly found in our societies. These are discussed below:

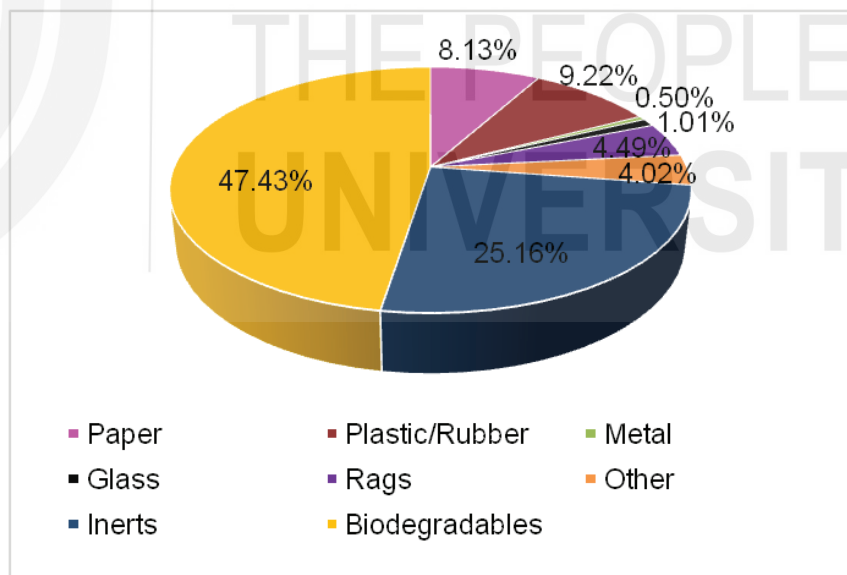
- a) **Domestic waste:** These wastes are produced at the household levels or from dwellings, apartments and residential buildings. These include leftover food, contaminated wastewater by the use of detergent, household garbage, ashes, furniture material, clothes, plastic and so on.
- b) **Agricultural waste:** These include wastes from the agricultural area or due to the result of agricultural activity and associated processes. These are organic wastes from plants and animals, spoiled food grains, crop residue after harvesting, contaminated water after the use of chemical fertilisers and pesticides and other agricultural remains.
- c) **Industrial waste:** The source of these types of wastes is industries, factories and several other manufacturing processing units. Various types of solid and liquid effluents are major wastes generated from here. It mainly consists of processed wastes, chemicals, tanneries, building material, burning of coal and wood, charcoal and ashes, hazardous solid and gaseous wastes are produced as a result of industrial activities.
- d) **Municipal waste:** The waste generated by various municipal activities while constructing roads, public facilities, buildings, railways lines, street cleaning, landscaping of an area, etc. are known as municipal wastes. Municipal solid waste (MSW) is defined to include household waste, commercial and market area waste, slaughter house waste, institutional waste (e.g., from schools, community halls), horticultural waste (from parks and gardens), waste from road sweeping, silt from drainage, and treated biomedical waste. If you observe Figure 10.1, which represents the Indian scenario of the different wastes share in the percentage of total municipal wastes.

- e) **Biomedical waste:** Wastes from hospitals, clinics, path labs, experimental labs in the form of blood, diseased organs, the material used during medical operations, poisonous gases during experiments and several such items are termed as biomedical wastes.
- f) **Waste from natural disasters:** After the occurrence of natural or human made disasters, various materials are left behind as waste. It includes slag and ash from a volcanic eruption, building debris after the earthquake/landslides, and various remains left behind due to flood, cyclone/tsunamis, fire, structural collapse, etc.

## 2. Classification based on Type

Based on the physical, chemical, and biological characteristics, wastes are classified mainly into two types: biodegradable and non-biodegradable wastes.

- i) **Biodegradable wastes:** These wastes are those leftover materials of organic matter which get degraded from complex to simpler compounds. These include paper, textiles, wood, food wastes, fruit and vegetable peels, etc. These are also produced as a result of various human activities at the household, industrial and commercial levels. National Environmental Engineering Research Institute (NEERI) is one of the Council of Scientific and Industrial Research (CSIR) laboratories established to conduct research and development studies in environmental science and engineering and also render assistance to the industries of the region, local bodies etc. in solving the problems of environmental pollution.



**Fig. 10.1: Composition of Municipal Solid Waste in India**

(Source: Municipal solid waste management manual Part II: 2016, CPHEEO, MUD, Govt. of India)

NEERI carried out the studies on assessment of status of municipal solid wastes management in metro cities and state capitals of India in 2004 for covering 59 cities (35 metro cities and 24 state capitals) across the country and observed that the waste generation rate varies from 0.12 to 0.60 kg/capita/day. Figure 10.1 shows the composition of wastes in India. It clarifies that nearly 47.5 per cent of waste is biodegradable waste

which is generated in India followed by 25.2 per cent of inerts, plastic (9.2%) and 8.1 per cent of paper.

- ii) **Non-biodegradable wastes:** These wastes include inorganic and to a certain extent recyclable waste products. It includes plastic wastes, glass wastes, cans, metals, etc.

You can understand by refereeing Table 10.1, the degeneration time of the biodegradable and non-biodegradable wastes. These wastes can further be categorized under different types of wastes as follows:

- a) **General garbage:** Garbage refers to wastes produced in the process of making, selling, preparing, handling, exporting and disposing of various materials and items. It includes solid as well as liquid wastes which may have an intolerable smell. Further, it invites various vermin, rats, pigs, due to which they require immediate attention for their time management.
- b) **Street waste:** Wastes collected from public places like streets, parks, parking areas, pathways, vacant areas etc. It includes huge dirt, dust, plant leaves, plastic wrappers, plastic bottles etc.
- c) **Plastic waste:** Various products and goods are made of and sale in different modes of plastics like carrying bags or water bottles which is frequently used. These plastics are mostly single-use plastics and thrown away after use. These single-use plastics are one of the major problems responsible for various environmental pollution across the world and needs attention.
- d) **Farm waste:** Farm wastes are similar to agricultural wastes and can create a critical problem with reference to the management of agricultural soil and groundwater contamination. This is an important challenge in front of agricultural planners.
- e) **E-waste:** Over-dependence of human beings on the electronic products has resulted in the generation of electronic waste. According to

**Table 10.1: The degeneration time for biodegradable and non-biodegradable wastes.**

Category	Type of waste	Approximate time taken to degenerate
Biodegradable	Vegetable and fruit peels, leftover foods, etc.	1 week to 1 month
	Paper	2 to 6 weeks
	Cotton cloth	2 to 6 months
	Woolen items	1 to 5 years
	Wood/boards	10-15 years
Non-biodegradable	Tin, aluminum and other metal items such as cans	50-500 years
	Plastic bags	10 to 1000 years
	Plastic bottles	500 years
	Tires	Nearly 2000 years
	Batteries	100 years
	Glass bottles	1 million plus years



India's Ministry of Environment and Forests "*electronic waste comprises of waste generated from used electronic devices and household appliances which are not fit for their intended use and are destined for recovery, recycling and disposal*". Various electronic appliances like television, computer, refrigerator, mobile phone, and air conditioners that have become ubiquitous in today's human life. Their associated discarded material like computer hardware, electronic devices used at homes and offices like mobiles, pen drives, irons, power plugs, wires, televisions, etc. are all e-wastes.

- f) **Nuclear waste:** Various types of nuclear waste from nuclear power plants is produced at the time of manufacturing of weapons, during experiments and their testing, etc., which are included under the category of nuclear wastes.
- g) **Hazardous wastes:** Hazardous wastes are those defined as wastes of industrial, institutional or consumer.

Besides, the above-discussed types, the list of wastes is quite long and besides, many other types of wastes can also be identified.

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### SAQ I

- a) What do you mean by wastes? What are major types of wastes?
- b) Which of the following statements are *false*? In each case explain why it is incorrect.
1. The peel of orange is non-biodegradable waste.
  2. Ashes are considered as domestic wastes only.
  3. Electronic products like power plugs, iron, etc. produce E-waste.

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## 10.3 EFFECTS OF SOLID AND LIQUID WASTES

As all we know that the quantity of waste is increasing day-by-day due to rapid growth of population and various services facilitating them to improve economic wellbeing. In doing this, huge waste is generated which is not getting disposed-off properly due to lack of space, workforce and unimproved mechanisms in the urban areas. In a result, it creates lots of problems for local people as well as for the surrounding environment in various ways. You know now some of the major effects of wastes.

### 10.3.1 Effects on Public Health

Solid wastes dumped at a place provide a suitable environment for the development of the vermin population. These vermin like mosquitoes, flies, rodents and pigs are the major agents of various types of diseases. These diseases become a health problem when they spread into the local community and surrounding area. Mosquitoes transmit malaria, chikungunya, dengue fevers, etc., whereas, flies spread typhoid, dysentery problems.

Rats (rodents) movements create conditions for the spread of the plague. For rats, solid wastes dumping areas are the main sources of food as well as provide shelters. Besides rodents, other animals like dogs, cats, and pigs are also the carriers of various diseases.

The people who are working in these areas are directly exposed to these diseases and are highly vulnerable. Sometimes, while handling solid or liquid wastes, they came across to contact with sharp edges of glass or metal and get skin and blood infections. Further, they are vulnerable to animal bites and associated diseases at solid waste disposal sites. They can experience eye and chronic respiratory diseases including cancer resulting from exposure to dust and hazardous materials. Burns and other injuries are also possible due to careless dumping of chemicals, acid, electronic waste materials leading to serious health hazards. The waste generated from hospitals and laboratories like syringe needles, swabs, bandages, etc. is very dangerous and infectious. Workers working with these chemicals and metals for research laboratories may experience toxic exposure. You have understood the major effects on human health by solid and liquid wastes. It is not limited to the public health, it also effects our environment so badly.

### **10.3.2 Effects on Environment**

Solid and liquid wastes have an adverse impact on the environment. The dumping of waste in open areas and drains creates lots of problems. The burning of wastes generate different types of pollution which affect the local population and also the environment. Improper burning of solid wastes led to air pollution at landfill sites. Emission in the form of carbon monoxide, particulate matter, nitrogen oxides, and sulphur oxides creates huge problems in the atmosphere.

Dumping of wastes in storm water drains leads to water pollution. When these drains move from the surrounding agricultural area also affects the local land and quality of groundwater. During the rain, the leaching of wastewater from the landfill sites gets mixed with groundwater and affects its quality. This contamination changes the chemical properties of groundwater which is harmful if it is being used in surrounding areas for agricultural or domestic purposes.

Foul odour produced from the decomposition of the solid and liquid wastes, has a significant effect on the environment. The obnoxious smell created by the huge piles of wastes and around the wastewater drains is unhygienic as well as intolerable when we move nearby. In residential areas also, the waste collection centres smell a lot. The smell is the result of the presence of mixed types of organic material. Further, these sites are affecting the visual attractiveness of the place. These sites located along the roads, highways, public/residential bins provide easy accessibility to animals, scavengers for the collection of food and other materials. Therefore, the environment of these areas is affected by solid and liquid wastes in various ways.

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### **SAQ 2**

List out major effects of waste on human and environmental health.

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## **10.4 SOLID AND LIQUID WASTE MANAGEMENT**

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One must understand that the significance of solid and liquid waste management (SLWM) because the wastes are vulnerable to local environment and public health as well. Both safety and care are very important in the management of wastes. There are several methods generally used in orderly execution of various functions of collection, transport, processing, treatment and disposal of municipal solid and liquid waste.

Actually, waste management is a complex task that depends upon organization and cooperation between households, communities, private enterprises, and municipal authorities. Therefore, solid and liquid waste management include various methods from the generation of waste to its collection, transportation, processing, recovery, and recycling. One should also adopt appropriate mix of processes and technologies for waste's collection, transfer, recycling, and disposal. The preferred waste management strategies can be grouped into various stages of processes. These are discussed below.

### **10.4.1 Reducing Generation of Wastes at Source**

We must consider reducing generation of wastes at the source, which is one of the best option in the waste management. Waste generation comprises any activity where materials are identified as having no value any longer and hence either thrown away or gathered (collected) for disposal. Waste generation requires its proper management process for a healthy living. Further, these wastes, useless to one individual, may not be useless to another. The generation of waste must be prevented at the initial stage itself in the planning of design, production, package, use and reuse of products and goods. Therefore, it helps to reduce not only economical costs but also environmental costs including the problems of leachate, emissions, and greenhouse gases. At every stage, raw materials should have the flexibility to convert into goods for consumption purposes.

### **10.4.2 Storage**

Storage involves a system of keeping waste material at a place when they have been discarded by the users in different areas. Different types of storage facilities include small containers, large containers and shallow pits, etc. These all vary in their size, form and material. The small containers are used at the household level; large containers are for institutions, commercial purposes. The different types of wastes are generated in the residential areas and should be removed at the earliest as it is likely to pollute the environment. The quantity and size of storage facilities depend upon the number of users, waste types, and accessibility to these wastes. Therefore, careful planning is done while these facilities are provided in an area. The safety of these structures from being theft or vandalized is also need to be ensured.

### **10.4.3 Collection**

Collection process of waste involves the ways by which wastes will be collected and transported to the disposal site, where the collection vehicles



get emptied (Ramachandra, 2006). This collection process depends on the volume of waste which will be managed by the frequency of collection. Therefore, the collection process is planned in such a way so that the disposal site doesn't become overloaded. You might be aware about Municipal Corporations which are local governing body mainly found in urban areas. It looks after the community services like health, education, housing and transport. The collection of waste is managed by Municipal Corporations and somewhere by franchised service methods. The collection of wastes can be analysed with the help of collection efficiency. It is the percentage of the total waste collected to the total waste generated.

#### 10.4.4 Transportation

You are aware that the transportation of the waste material will finally reach to a particular disposal site. In the process, various modes of transport are adopted depending upon the amount and availability of waste to be transported. It is carried with the help of motorized vehicles or by human and animal-driven transportation methods. The transfer of wastes is also taken place from smaller vehicles as they can access narrow lanes/streets and larger vehicles to transfer it to the disposal sites. The indiscriminate dumping of collected waste sometimes in non-allocated areas, vacant lots, alleys, ditches that leads to clogging of drains and sewage systems. It will further help to increase of breeding grounds for rodents and insects, these spread diseases.

#### 10.4.5 Waste Processing

The waste processing includes changing of the physical and chemical properties of wastes for further use by recovery and recycling methods. This processing helps to get the best amount of benefits through waste management. The objective of processing the waste is to improve efficiency in waste management, recovering materials for use, and recovering conversion products and energy. Waste processing techniques involve compaction, separating waste components, incineration, and composting.



(a)

(b)

**Fig. 10.2: Waste management a) transportation by motorized vehicle and b) dry, wet and domestic hazardous waste collecting bins.**

(Source: Municipal solid waste management manual Part II: 2016, CPHEEO, MUD, Govt. of India)

### 10.4.6 Recycling and Recovery

You might be knowing that one of the objectives of waste management is to improve efficiency in waste management, the recycling and recovering of waste material. Recovery of recyclable materials and strengthening a waste through recycling process to create a new product plays a very critical role. It has been stated that recovery is a function of economics. It means the cost of separated items versus the quantity of the number of recovered products. Various recovered products have a different value in the market as they can be recycled and reused in modified form. Plastics, tin, glass, paper and cardboard, etc. related items can be recovered, recycled and further reused for different purposes. The important recycling materials and their recycling potential is explained in Table 10.2.

**Table 10.2: Recycling materials and their conditions.**

Recyclable Material	Potential for Recycling	Special Conditions
Aluminium	<ul style="list-style-type: none"> <li>• It can be recycled easily by shredding and melting as it is not deteriorated in reprocessing.</li> <li>• It requires significantly less energy than producing aluminium ore.</li> <li>• Market value is high.</li> </ul>	Separate collection is important
Batteries	<ul style="list-style-type: none"> <li>• It recovers valuable metals.</li> <li>• It protects environment from heavy metals such as lead, cadmium, and mercury.</li> </ul>	<ul style="list-style-type: none"> <li>• There is a large variety in types and sizes of batteries.</li> <li>• Only some types allow adequate material recovery.</li> </ul>
Glass	<ul style="list-style-type: none"> <li>• It can be melted and sorted into colours.</li> <li>• Recycling glass saves energy compared with processing raw material.</li> <li>• It can be recycled indefinitely because it does not deteriorate through reprocessing.</li> <li>• Good market value.</li> </ul>	Broken glass can contaminate and eliminate opportunities for recycling of other material such as paper.
Paper and cardboard	<ul style="list-style-type: none"> <li>• Paper or cardboard from recycled paper requires less energy during production.</li> <li>• Easy recycle process.</li> </ul>	Quality of recycled product decreases with every processing cycle.
Polyethylene terephthalate (PET)	It can be recycled if segregated from other waste.	<ul style="list-style-type: none"> <li>• Quality of recycled product decreases with every processing cycle.</li> <li>• Recycled products</li> </ul>

		only for specific designated uses.
Other plastics	<ul style="list-style-type: none"> <li>• Other plastics, such as polyethylene or polyvinyl chloride, can be recycled.</li> <li>• Low market value than PET.</li> </ul>	<ul style="list-style-type: none"> <li>• Clean segregated plastics, are subjected to mechanical recycling into the same plastic type.</li> <li>• Where recycling is not possible due to mixed plastics, they are then co-processed for energy recovery or used as aggregates in road material.</li> </ul>
Electronic waste	<ul style="list-style-type: none"> <li>• Electronic items can be dismantled and its components reused or recycled.</li> <li>• It contains high value metals.</li> </ul>	If recycling is not carried out under controlled conditions, metal is often covered with polyvinyl chloride or resins, which are often smelted or burned, causing toxic emissions.
Metal (steel, copper, nickel, zinc, silver, etc.)	<ul style="list-style-type: none"> <li>• It can be recycled indefinitely because it does not deteriorate through reprocessing.</li> <li>• Scrap metal has a high market value, especially steel, copper, and silver.</li> </ul>	High value metals, such as copper and silver, are incorporated in electronic devices, but extraction can cause severe environmental impacts, if uncontrolled.
Thermocol or Styrofoam	<ul style="list-style-type: none"> <li>• It can be processed to recover fuel and other by-products.</li> <li>• It can be powdered and made into sheets, which can be used to make furniture.</li> </ul>	<ul style="list-style-type: none"> <li>• Fuel production is through pyrolysis, gasification, and hydrocracking.</li> <li>• Regulated facilities with appropriate environmental controls are required for handling thermocol recycling.</li> </ul>
Construction and demolition waste	Demolition waste can be sorted, crushed and reused for production of pavement material, flooring tiles, road construction, landscaping and other purposes.	Standards for recycled products are yet to be stipulated.

(Source: Municipal solid waste management manual Part II: 2016, CPHEEO, MUD, Govt. of India)

### 10.4.7 Waste Disposal

The final stage of solid and liquid waste management process is the waste disposal. Waste of every type, as discussed above, needs to be disposed-off, properly. Waste disposal should be done in such a way so that it should not harm the local environment as well as the health of the people living nearby. For this purpose, landfill sites are identified under the landuse planning of a region. It requires engineering methods so that its impacts are minimal. The Government of India stipulated regulations of the Solid Waste Management Rules, 2016 for proper disposal of residual wastes in sanitary and lined landfills, etc. The documents are available at <http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php>. The advanced technological tools like Geographic Information System (GIS) software is used in monitoring waste disposable trucks, these trucks installed with Global Positioning System (GPS) technology. The GPS enabled trucks can easily be monitored their irregularities in waste transportation and disposal systems.

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#### SAQ 3

Which of the following True or False.

- a) Municipal Corporations are designated for solid waste management activities in villages and cities.
  - b) The objective of processing waste is to improve efficiency in waste management.
  - c) Glass materials cannot be recycled.
  - d) Wastes associated with television, computer, refrigerators, mobile phones, and air conditioners are a major part of e-waste.
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### 10.5 SUMMARY

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In this unit, you have studied:

- The solid and liquid wastes are of various types and classified on various bases.
- It has been found that mismanagement of wastes has to lead to various impacts on the environment and public health.
- Waste management is emerging as an important challenge in the metropolitan cities where they are rising very rapidly. Therefore, efficient waste management is the only option through which we can tackle this problem.
- Various stages in waste management help to handle waste effectively. The various methods of waste management like storage, collection, processing, recycling, recovering and disposal will bring to reduce the pressure on the environment and in the functioning of a healthy urban ecosystem.

You will study about the concept of biodiversity, various factors affect the biodiversity loss and its impacts on environment, and the management of biodiversity loss in the next Unit 11.

## 10.6 TERMINAL QUESTIONS

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1. Define wastes. Classify the waste based on the source of origin.
2. Differentiate between biodegradable and non-biodegradable wastes.
3. Explain the effects of solid and liquid wastes on environment.
4. Discuss in detail the major stages of waste management.

## 10.7 ANSWERS

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### Self-Assessment Questions

1. a) Waste means unwanted or useless materials. They are found in solid, liquid and gaseous state.  
b) 1. False. It is degenerated in the environment.  
2. False. Ash can be released from the burning of agriculture residues and also from industries.  
3. True
2. Solid and liquid wastes are leading to spread diseases like fevers, dysentery, plague, bad smell, etc. in humans and also effects the environment in the way of deteriorating groundwater quality and air pollution due to leakages and emissions, the loss of beauty of dumping areas, etc.
3. a) False   b) True   c) False   d) True

### Terminal Questions

1. Based on the source or origin, the most common types of wastes are domestic, agricultural, industrial, municipal and biomedical wastes. Refer to Section 10.2.
2. Based on degradation properties, wastes are of two types: biodegradable and non-biodegradable wastes. Refer to Section 10.2.
3. Refer to Section 10.3.
4. Waste management depends upon organisation and cooperation between households, communities, etc., therefore, solid and liquid waste management uses various methods from the generation of waste to its collection, transportation, processing, recovery, and recycling. Refer to Section 10.4.



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