UNIT 10

WASTE MANAGEMENT

Structure

10.1 INTRODUCTION

In the previous unit you have learnt about environmental pollution and the factors responsible for generations of pollutants. In the present unit we shall discuss the waste and as to how it can be disposed off with minimum harm to the environment.

You know that living beings require food. They use food for their growth and development and for producing energy. In this process they also generate wastes. Industries also use raw materials, process them to yield useful products and are left with wastes which may sometimes exceed 50 per cent of the raw materials used. We have learnt that unlike natural ecosystems which can cope with the demand for food as well as the disposal of the wastes, in the case of industries, the waste can go on accumulating unless properly disposed off. Some of this waste is hazardous in nature, and may need special care with regard to diposal.

Although hazardous waste chemicals make up to 15 per cent of the total industrial wastes, their extremely dangerous nature requires that they be properly and carefully disposed off. If this waste is not judiciously disposed off, the natural resources can be seriously

contaminated and may pose a serious threat to the quality of environment in general and human health in particular. Various methods of hazardous waste disposal have been described in this unit. You will also learn in this unit about the concept of hazardous waste management, i.e., what treatment a waste should undergo before disposal, and what are the after-effects of improperly disposed wastes in the long run. A special mention will be made about waste management in India.

Expected Learning Outcomes

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

- ❖ define and classify the hazardous waste chemicals and distinguish' them from toxic chemicals;
- ❖ explain the pre-requisites of hazardous waste management;
- ❖ compare and contrast various methods for disposal of hazardous wastes;
- ❖ describe how hazardous waste is being disposed off presently in our country; and
- ❖ appreciate the impact of improper management of hazardous waste chemicals.

10.2 HAZARDOUS WASTES

Every day millions of tonnes of municipal solid waste, industrial waste and biomedical waste is generated in our country. This is a valuable material and energy resource if recycled and reused.

Municipal solid waste is generated mainly from residential and commercial complexes in urban areas and consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. The amount of municipal solid waste has been increasing rapidly and its composition changing with increasing urbanization and change in lifestyle and food habits. In 1947, cities and towns in India generated an estimated 6 million tonnes of solid waste. In 1997, it was about 48 million tonnes, and in 2008 it become 68.8 million tonnes. Waste disposal is a major problem with more than 25% of the municipal solid waste not being collected at all. Most Indian cities lack adequate capacity to transport waste and there are no sanitary landfills to dispose it of. The existing landfills are neither well equipped nor well managed and are not lined properly to protect against contamination of soil and groundwater.

Hazardous wastes are chemical by-products of an industry, a factory or a chemical plant. They may result from household activities or even from a hospital or a research laboratory. Armed conflicts, where nuclear or chemical weapons are used, also release enormous amounts of hazardous wastes. A chemical produced by any of the above sources which may endanger human health, pollute the environment or carry hidden risk to life if managed or disposed off improperly is called **'hazardous'**. A waste is considered as hazardous if it has any one of the following characteristics:

The four broad categories of garbage are:
Organic waste: kitchen waste, vegetable, flowers, leaves, fruits.

Recyclable: paper, glass, metals, and plastics.

Soiled: hospital waste such as cloth soiled with blood and other body fluids.

Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish etc.

- Ignitability - catches fire easily;
- Corrosiveness - wears away other materials;
- Reactivity - reacts strongly with water or explodes on reaction with other chemicals;
- Radioactivity - releases ionizing radiations;
- Toxicity - produces symptoms of metabolic disorders, poisoning, disease, mutations, cancer or malformations.

10.2.1 Toxic Versus Hazardous

A compound, microorganism or an agent which causes symptoms of ailments such as vomiting, giddiness, diarrhea or the like, is said to be pathogenic. If it induces genetic changes on consumption, it is said to be mutagenic. If it causes formation of galls or morphological abnormalities, it is known as teratogenic. And if it causes cancer, it is said to be carcinogenic.

Generally, the terms **"toxic"** and **"hazardous"** are used interchangeably as if they are synonymous. But this is not true. **"Toxic"** defines the capacity of a substance to produce injury after entering the metabolic processes of the consumer, an animal, a plant or a human being. This may result in disease, genetic changes, abnormally or may cause cancer.

The term 'hazardous' denotes the potential of a substance to pose threat to life or material through any one of the properties mentioned above, namely, toxicity, ignitibility, corrosiveness, reactivity, explosiveness or radioactivity. The term "hazardous" is thus broader and includes "toxic" wastes in its spectrum.

You can see that some substances may be hazardous on more than one account. For example, benzene is toxic as well as ignitable; strong acids and alkalis form corrosive mixtures which sometimes explode if improperly handled.

SAQ 1

Fill in the blanks using appropriate words and compare your answers with those given at the end of this unit:

i) A compound which induces genetic changes on consumption is said to be .....if it causes formation of galls or morphological abnormalities it is known as ..... and if it causes cancer, it is said to be .....

ii) A waste is proposed as hazardous if it has any one of the following characteristics:

   a) ....., i.e., catches fire easily

   b) ....., i.e., wears away other materials

   c) ....., i.e., reacts strongly with water

   d) ....., i.e., releases ionising radiations

   e) ....., i.e., produces symptoms of poisoning

iii) A complete definition of "hazardous waste" includes the physical, chemical or biological properties of a waste which because of its quantity or concentration may

a) cause or significantly contribute to an increase in ..... or an increase in serious ..... or incapacitating ..... illness, or

b) pose a substantial presence or ..... hazard to human health or the environment when improperly ....., ..., transported or ..... off, or otherwise managed.

10.3 CONCEPT OF WASTE MANAGEMENT

Hazardous wastes have become an important environmental and public health issue which concerns many countries in the world. In the modem framework of hazardous waste management, a four pronged strategy has been adopted:

i) Minimising the quantity of waste

ii) Recycling of industrial waste

iii) Treatment of the waste

iv) Collection, transport and disposal of waste in an environment friendly manner. The generalized scheme of recycling is given in figure 10.1.

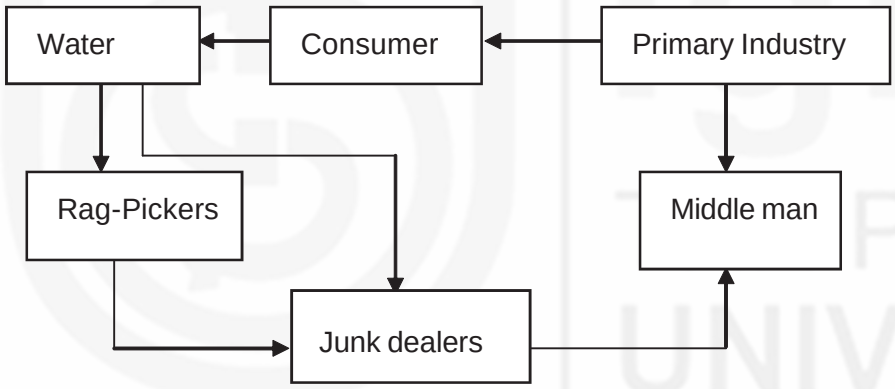

Fig. 10.1: Recycling of Wastes.

10.3.1 Waste Minimisation

The first priority in hazardous waste management is to reduce the quantity of waste to minimum. Three major waste reduction schemes which are often used can be summarised as below:

i) Process Modification: Often the industrial process can be altered in such a way that the use of raw materials is optimised and the amount of hazardous waste is reduced to barest minimum.

ii) Waste Concentration: The waste can be concentrated using evaporation, precipitation or decantation techniques which mean that the volume of waste can be considerably reduced using these methods. Incineration, viz., oxidation of inflammable. Waste is often practised in order to reduce the volume of waste to be handled.

iii) Waste Segregation: Segregating the hazardous waste streams from non-hazardous streams decreases the volume of hazardous wastes; thus, making it easier to treat.

Recycling: Some Benefits

- Conserves resources;
- Saves energy;
- Prevents emissions of many greenhouse gases and water pollutants;
- Supplies valuable raw materials to industry;
- Stimulates the development of greener technologies;
- Reduces the need for new landfills and incinerators;
- Creates jobs.

Various ways of Reusing things:

- Turn empty jars into containers for leftover food or pots for growing plants.
- Use cloth napkin or towels.
- Refill bottles.
- Use durable ceramic mugs.
- Donate old magazines or surplus equipment.
- Reuse boxes.
- Purchase refillable pens and pencils.

10.3.2 Recycling Industrial Wastes

Many substances in refuse wastes have value. They include glass, wood fibre from paper products, plastics and metals. Scientists have developed ways of recycling many wastes so that they can be used again. Almost all materials are recyclable. However, in some, more energy will be used in recovery than the recovered value warrants.

Scraps and Used Metals

Scrap metal is produced in large quantities in mills and factories. Old used metal from discarded vehicles, machine, aircrafts, ships, buildings etc. (Fig. 10.2) can be melted and recycled for useful purposes (Fig. 10.3). Aluminum scrap and aluminum utensils, for example, can be collected, melted and shaped into new utensils. We can meet the growing demand of such scarce metals as copper, zinc, lead, platinum by recycling the metal scrap.

Fig. 10.2: The richest one we have – our mountains of scrapped cars – offers a rich, inexpensive, and ecologically beneficial resource that can be "mined" for a number of metals.

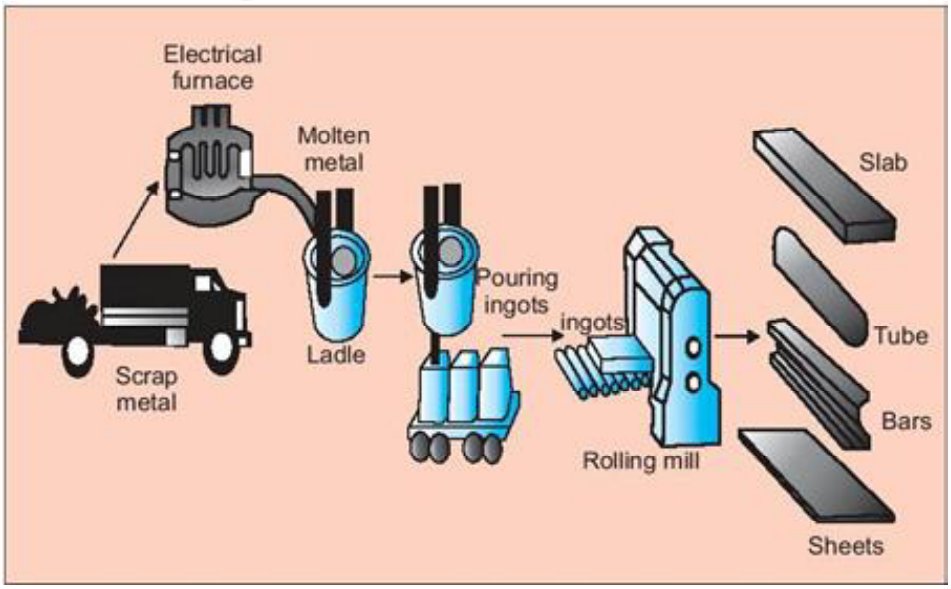

Fig. 10.3: "Minimills" remelt and reshape scrap iron and steel.

SAQ 2

A. Fill in the blanks using appropriate words :

i) Hazardous waste must undergo the following four steps before it can be disposed in an environmentally sound manner.

a) ..... of the quantity of waste

b) ..... of industrial waste

c) ..... of the waste

d) ..... and disposal of waste

ii) Minimisation of the volume of waste is achieved through the following three ways:

a) ..... modification

b) ..... of waste and

c) ..... segmentation.

iii) Transfer of waste “as is” without reprocessing, to another facility is known as waste ..... When a transfer “as is” is not possible, and it needs reprocessing for material recovery before it can be used in factory, then it is known as waste .....

B. State whether the following statements are **true** or **false**.

a) The first priority in hazardous waste management is to reduce the quantity of waste to minimum.

b) Incineration is an excellent method of waste disposal but its cost of operation is high.

c) There is no way for effective, cheap and environmentally safe disposal of hazardous wastes.

d) When a waste requires treatment before use it is known as **waste reuse**.

10.3.3 Treatment of Hazardous Wastes

After material recovery, the waste water containing hazardous waste chemicals should be detoxified and neutralised through treatment. There are many technologies available for treating hazardous wastes before they are ultimately disposed off. Their aim is to modify the physical and/or chemical properties of the wastes so that they are rendered harmless. Selection of a treatment process depends on many factors such as the nature of the waste, the desired characteristics of the output stream, and economic and energy considerations. The treatment technologies can be divided into the following groups, namely:

- physical treatment
- chemical treatment

- biological treatment
- solidification, and
- incineration

Physical treatment: This is conducted using various methods such as phase separation. Phase separation includes three steps, namely: lagooning, prolonged storage in tanks and sludge drying in beds. Lagooning and tank storage are collectively used to separate particulate impurities.

Chemical treatment: This is used to facilitate complete breakdown of hazardous wastes and more usually to modify the chemical properties of the wastes, e.g., to reduce water solubility or to neutralise acidity or alkalinity. The techniques involve oxidation, chemical reduction, neutralisation, heavy metal precipitation, oil/water separation and solvents/fuels recovery.

Biological treatment: The gross impurities obtained from treatment of sewage are collectively known as sludge, which is given biological treatment, before disposal. This is known as sludge processing which has become important since improvements in industrial waste water treatment. The typical technologies for sludge processing include conditioning, digestion, composting, thickening or dewatering and solidification.

i) **Conditioning:** In this step the sludge is exposed to atmosphere for a stipulated period until a desired consistency is reached.

ii) **Digestion:** In this process the sludge is treated with bacteria which break down the long chain compounds into simpler ones.

iii) **Composting:** In this step the organic matter in the waste sludge is converted into a usable stable material.

Box 10.1 : Waste Water Treatment

Domestic and municipal waste is rich in organic matter. If this kind of water is made free from disease carrying germs and poisonous elements, it can be used for irrigation of farms, gardens and other vegetations.For the removal of organic waste, sewage is treated in a tank or in ponds for several days (Fig. 10.4). In doing so, the heavy particles settle down to the bottom by themselves, while the finer particles are made to settle down by adding alum and caustic soda.

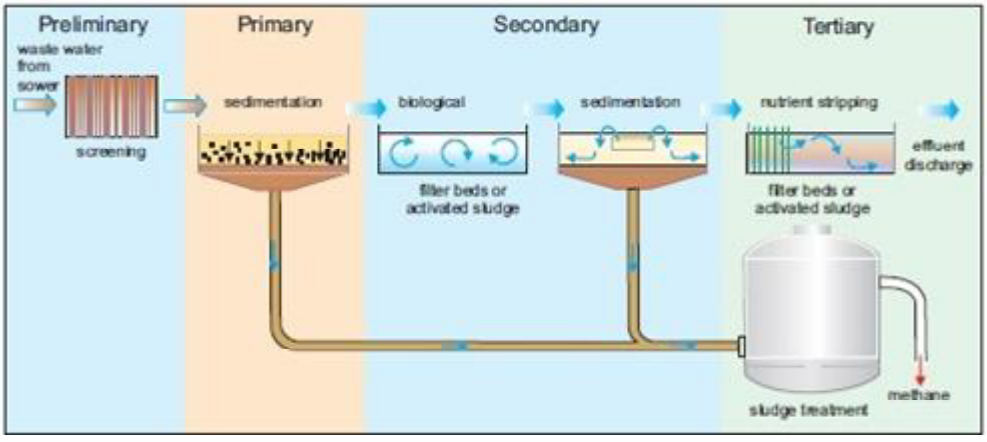

Fig. 10.4: Sewage treatment processes.

The clear liquid is then allowed to pass through filters or sand or earth and finally air is blown through it. This treatment not only removes organic wastes but also removes hydrogen sulphide which is generally dissolved in waste water, adds oxygen to the filtered water, thus help in water purification. Treatment of water with appropriate doses of chlorine, known as chlorination, That kills the harmful germs and makes the water usable.

Solidification: This process converts the liquid waste into insoluble, rock-hard material and are used as pre-treatment prior to landfill disposal. This is usually done by mixing the waste with various reactants to produce a solid mass. The basic aim of solidification process is to immobilise the hazardous constituents of the waste, so that these do not leach out at the landfill disposal site.

Incineration: Apart from the above mentioned methods, incineration is also a method of detoxification, in which oxidation of waste detoxifies the waste from its toxic proportion, about which you will read in section 10.4.2.

10.3.4 Solid Waste Management

Before disposal, a waste should be considered for the following possibilities:

- Reduction in raw materials and solid waste quantities
- Reuse of waste materials
- Materials recovery
- Energy recovery

I) **Reduction in Raw Materials and Solid Waste :** This can be achieved by : i) reducing the amount of materials used in the manufacture of a product, ii) increasing the life of the product, and iii) reducing the amount of materials used for packing the consumer goods.

II) **Reuse of Waste Materials :** Reuse of waste materials now occurs most commonly in those situations where a product has utility in more than one applications. For example, the paper bags used to bring home groceries are used to store household wastes. Soup and vegetable containers are used to store cooking medium, like ghee or oil. Plastics bottles are reused to store water.

III) **Material Recovery and Recycling :** A number of materials present in municipal and industrial wastes are suitable for recovery and recycling. About 10-15 per cent of solid wastes are recoverable. Most suitable materials are the wastes generated by paper, cardboard, glass, ferrous metals, non-ferrous metals (mostly aluminium), plastics and rubber. On the contrary, leather, textile and food wastes are unsuitable candidates for materials recovery. Fly ash from thermal power plants can be used to make bricks for construction.

IV) **Energy Recovery :** After segregation of wastes in the above-mentioned categories, the remainder is considered for the recovery of heat by burning (incineration). Because, about 70 per cent of the components that comprise solid waste are organic, the potential for recovery of heat energy is high. The energy content in the waste matter is converted to a form that can be used more easily. The remainder (ash) is also more compact and weighs less, occupying a smaller volume.

SAQ 3

Fill in the blanks using appropriate words:

i) After material recovery, the waste should be ..... and ..... through treatment, which means to modify the physical and/or chemical properties of the wastes in such a way that the wastes are rendered ……..

ii) Selection of a treatment process depends on many factors such as nature of the wastes, desired characteristics of the ..... and economic and ..... considerations.

iii) Physical treatment is conducted using various methods such as phase separation, which includes three steps, namely ....., ……. in beds and prolonged ……..... in tanks.

iv) Sludge processing includes, ……....., ..., ... ……. or dewatering and solidification.

v) Incineration, which is ..... of wastes, is another method of detoxification of inflammable wastes. This method minimises the ……..,.....……..... of waste to be handled as well.

10.4 DISPOSAL OF WASTE

As cities grow in size with a rise in population, the amount of waste generated will increase. The local corporations in cities adopt disposal of waste. In this process tremendous scope exists for reducing, reusing and recycling the waste as shown in figure 10.5

Amongst the various categories of waste, hospital waste like soiled bandages, disposables, cultures, anatomical wastes, chemical wastes, discarded medicines pose grave environmental risk. This waste is highly infectious and needs to be managed in a scientific manner.

The final disposal of the hazardous wastes also needs to be carefully planned. There are four different ways in which hazardous wastes can be finally disposed. These four different ways are as follows:

- Landfill disposal.
- Incineration
- Dumping at sea
- Underground disposal

We shall now discuss each of the above method of disposal of wastes.

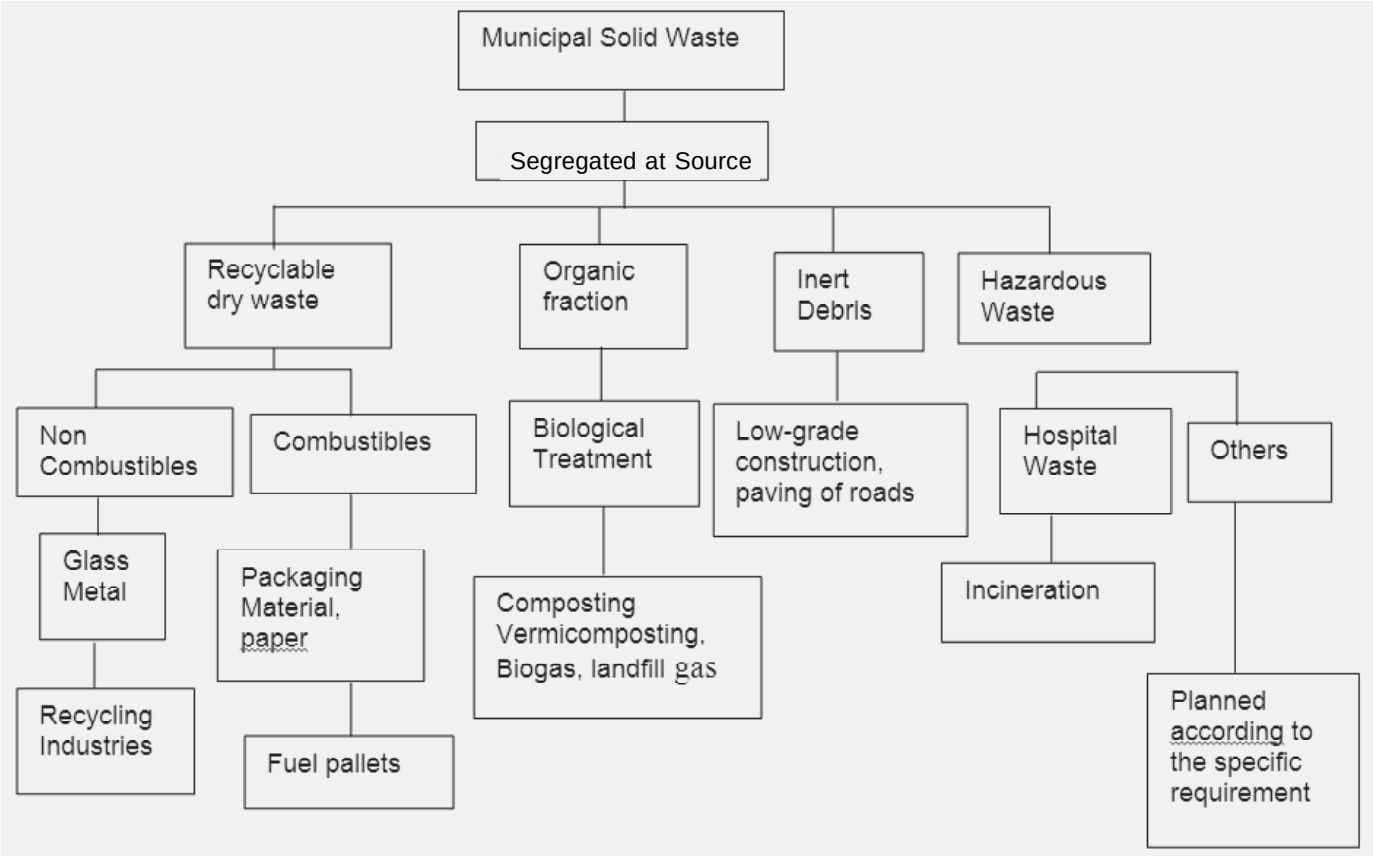

Fig. 10.5: Steps involved in the management of municipal solid waste.

10.4.1 Landfill Disposal

The disposal of hazardous waste by landfilling is an important method of disposal in many countries. Landfilling means under ground storing of harmful substances. This involves hauling the refuse to an area allocated for this purpose. In India, such areas range from unsanitary **open dumps** to properly operated **sanitary landfills. Open dumps** are a poor method of waste disposal because they cause environmental problems. For example, they can ruin the appearance of ah area and provide a home for rats and other rodents who spread disease. If garbage is exposed, it rots and smells foul. Most dumps allow some burning, which fills the surroundings with smoke. In addition, rain water can drain through refuse and carry harmful substances to streams.

Properly operated **sanitary landfills** cause little damage to the environment. The area to be filled with waste must be lined with a nonporous substance such as clay, or high density polyethylene (HDPE)-plastic membrane to

prevent the wastes from leaking to the surrounding areas. The wastes are packed and dumped at the site and covered with earth each day. The cover of earth prevents insects and rodents from getting into refuse. Operators of these sites forbid burning. In time, sanitary landfill sites become filled up, many communities then cover the site for a final time and use the area for recreational purpose.

A typical landfill site consists of an artificial double liner at the bottom and a cover at the top. The cross section of a conceptual design of a double lined hazardous landfill is shown in Fig. 10.6.

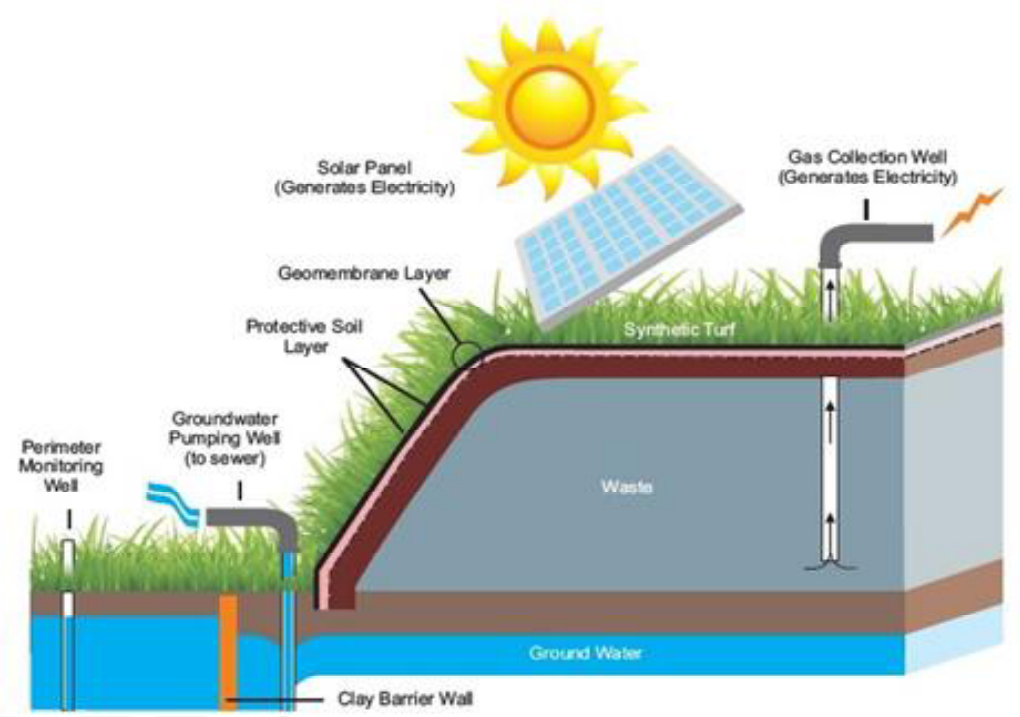

Fig. 10.6: Outline of a typical landfill site.

10.4.2 Incineration

Incineration burns waste products. This is another method many industries and large cities use if they do not have enough vacant areas for disposal sites nearby. Most hazardous wastes are detoxified in this process. This is also an excellent method of waste minimisation, waste detoxification and disposal, but its cost of operation is very high, if the heat content of waste is not reutilised.

The selection of incineration depends on the type and characteristics of the waste. A typical incinerator consists of a combustion chamber, burner chamber, precooler, scrubber, exhaust fan and stack to let out the gases (Fig 10.7).

10.4.3 Dumping at Sea

Another method of disposal of hazardous wastes involves dumping wastes at deep sea, designed to prevent contamination of groundwater. Disposal at sea,

of waste generated on land, is based on the misconceived notion that the enoromous volume of water available for dilution, enables the seas to be used as a dump without permanent damage. However, this is an erroneous conviction.

Disposal of waste at sea is controlled by international legislation and by the national legislation. The international legislation bans the dumping of extraordinarily hazardous wastes such as organic silicon compounds, halogenated organics, mercury and its compounds, cadmium, carcinogenic waste and plastics into the sea.

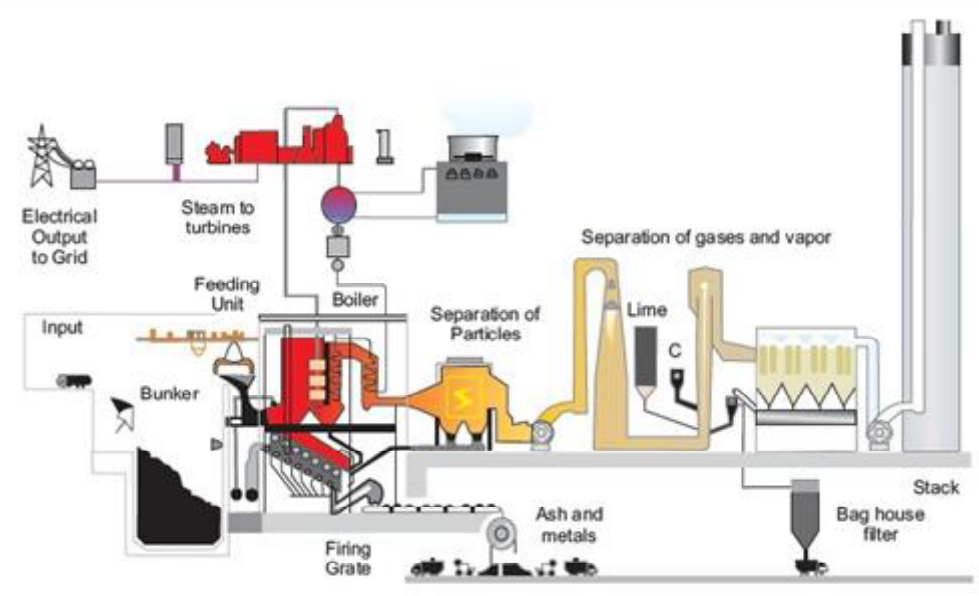

Fig. 10.7: A typical hazardous waste incineration unit.

10.4.4 Underground Disposal

It may be excessively expensive to dispose off certain hazardous wastes, such as radioactive nuclear wastes, in an environmentally acceptable manner at landfill still sites or incinerate them at thermal treatment plants. These wastes are generated in all operations associated with the use of nuclear energy for national defence or peaceful purposes such as mining of radioactive ore, production of nuclear fuel, laboratory experiments and medical treatment. Underground disposal may provide an environmentally and economically viable option in case of radioactive wastes. The underground disposal of hazardous waste is acceptable only in inactive or partially active mines that meet specific geological and technical criteria. Worldwide, only one deep-mine disposal facility is currently in operation: a worked-out halite/potash salt mine at Herfa Neurode in the Federal Republic of Germany (now united Germany).

Thus, in principle you have learnt that there are four methods of waste disposal.

You will see in the coming sub-sections as to how these methods are actually practiced under field condition.

SAQ 4

Fill in the blanks using appropriate words:

i) Problems of hazardous waste disposal arise from the fact that (a) waste in general has no perceptible ……..... value to the generator; (b) the chemical and physical ……..... may not be known; and (c) mixing of ..... wastes for convenience could create an acute hazard.

ii) Insanitary open dumps are a poor method of waste disposal because it provide home for ……..……... garbage rots and smells ……..... burning of garbage fills the surroundings with ……..... and rain water may carry ……..... substances to streams.

iii) Properly operated sanitary ……..... cause no damage to the environment. The area to be filled with waste must be lined with ……..... substance such as clay or HDPE-polyethylene membrane, to prevent the waste from ..... to the surrounding areas.

10.5 WASTE MANAGEMENT IN INDIA

We would now briefly discuss generation and disposal of hazardous waste in India.

10.5.1 Sources of Waste Generation

In general, hazardous waste generation can be broadly grouped into two categories, viz., Process-oriented and Pollution Control-oriented. The process-oriented waste is generated during the processing of raw materials to get the finished products; while pollution control-oriented waste originates from the treatment of gaseous and liquid effluents.

In India, there are industries generating large quantities of solid waste with relatively less concentration of hazardous constituents, (e.g., metallurgical industry like iron and steel, fertilisers, thermal power stations.). On the other hand, there are other groups of industries dealing with pesticides, electroplating, metal finishing, chlor-alkali and photographic chemicals which generate comparatively less quantity of solid waste but with high concentration of toxic and hazardous constituents. The later type of wastes requires special handling, storage, treatment and disposal techniques.

Nearly 15 per cent of the total solid waste generated by the industries, comes under the hazardous waste category. Though hazardous

wastes account for a small proportion of all wastes, their impact can be disastrous as they not only seriously affect the environment but also endanger the human health through inclusion in the food chain.

10.5.2 Prevalent Methods of Disposal

In the absence of proper regulatory control over handling, treatment and disposal, the hazardous wastes are mostly disposed wherever the space is easily available and accessible to the waste generators. Presently, the following methods of disposal of hazardous industrial wastes are followed in our country:

- Disposal along with city refuse
- Disposal on river beds and banks
- Open-pit burning
- Disposal in low lying areas, estuaries and seas
- Burning in self-designed incinerators.

Most of the heavy metal bearing and highly toxic wastes such as pesticides, solvent distillates, phenolics and cyanide waste are being disposed off using above mentioned methods. From the standpoint of impact what is significant is the method of disposal and the compatibility and complex interaction of these wastes with the receiving environment. Let us study what are the harmful effects of disposal of wastes in an improper way.

Ministry of Environment, Forest and climate change has notified solid waste management rules 2016. The rules make in mandatory for every waste generator to segregate and store separately recyclable, non-recyclable and hazards wastes and separately hand over these to the municipal workers.

10.6 IMPACT OF IMPROPER WASTE DISPOSAL

Improper disposal of hazardous waste causes adverse effects on human health and the environment. The normal practices of waste disposal such as insanitary open dump, landfilling, discharge in water courses, or open-pit burning will need modification when dealing with hazardous wastes. The principal hazard of improper waste disposal is contamination of soil and groundwater. This arises largely from the waste containing hazardous substances deposited landfills or on the ground. Fig. 10.8 illustrates in a simplified manner the mechanisms through which hazardous substances can enter the human environment after being “disposed of” in a landfill.

Fig. 10.8: Possible mechanism through which hazardous substances enter the human environment after being disposed off in landfill.

With regard to hazardous waste disposal sites, at least five different routes of human exposure are possible:

i) direct ingestion through drinking

ii) inhalation of contaminants that volatilise from heated water

iii) absorption through the skin during washing and bathing

iv) ingestion through consumption of goods derived from plants or animals exposed to polluted groundwater, and

v) absorption through the skin when handling contaminated soil.

A worldwide awareness has been created amongst the public against the improper and uncontrolled dumping of hazardous wastes. Such practices have brought about the death of livestock and ill-health in humans.

Plastics are indispensable part of our life. These are not biodegradable, but can be reused and recycled. Yet, single-use plastic products such as bottles, bags, packaging materials and cups and plates thrown carefully pose a big problem in India. These clog drains and even kill animals that accidentally swallow it in to their gut. Their segregation and recyclable can solve the problem.

SAQ 5

Fill in the blanks using appropriate words:

i) Presently, the principal methods of industrial waste disposal in our country are :

a) Disposal along with …….....

b) Disposal in ..... areas

c) Disposal in river beds and …….....

d) Disposal into ..... and sea

e) ……..... burning

f) Burning in self-designed.....

ii) The principal hazard of improper waste disposal is the contamination of ……..... and …….....

iii) Some wastes pollute rivers or lakes and others contaminate ……..... and poison people.

iv) Certain harmful wastes may pollute the ……..... or create a ..... hazard.

10.7 SUMMARY

In this unit we have learnt that:

- As a basic principle, hazardous wastes should be so managed that adverse effects to the welfare of the community are minimised.
- Wastes can be reused or recycled, in order to minimise the volume of waste to be disposed. Toxic waste must be treated before disposal. This can be done using chemical, physical or biological means. After detoxification, the waste should be carefully transported avoiding mixing of non-compatible chemicals.
- This follows disposal of waste into a properly operated sanitary landfill. The waste can also be incinerated or dumped in underground salt mines.
- We have also learnt about the harmful effects of improper disposal of wastes in India as well as in other countries.
- Management of city waste with emphasis on minimisation, reuse, and recycling, is one of the best means of conservation of resources.

10.8 TERMINAL QUESTIONS

1. What is the difference between Toxic and Hazardous Wastes?
2. State if the following statements are True or False.

   i) Toxic refers to an extrinsic property.

   ii) Exclusive list system of waste classification has been followed in most of the countries.

iii) Oily sludge has to be landfilled.

iv) Hospital waste has to be incinerated.

v) Pollution control facilities do not generate hazardous waste.

3. What strategy should be adopted for hazardous waste management?

4. State the kind of chemical wastes which need special kinds of technologies if they are to be incinerated.

5. Give one example each of waste reuse and waste recycle.

6. Differentate between process oriented and pollution control oriented waste generation with suitable examples.

10.9 ANSWERS

Self-Assessment Questions

1. i. mutagenic, teratogenic, carcinogenic

   ii. a) ignitability b) corrossiveness c) reactivity d) radioactivity e) toxicity

   iii. a) Mortality, irreversible, reversible b) potential, treated, stored, disposed

2. A. i) d) minimisation, c) recycling, b) treatment, a) collection, transport

   ii) a) process, b) concentration, c) waste

   iii) reuse, recycling

   B. i) True ii) True iii) False iv) False

3. i. detoxified, neutralised, harmless

   ii. output stream, energy

   iii. lagooning, sludge drying, storage

   iv. conditioning, digestion, composting, thickening

   v. oxidation, volume

4. i. economic, properties, non-compatible

   ii. home, foul, smoke, harmful

   iii. landfills, non-porous, leaking

5. i. f) city refuse, e) low-lying, d) banks, e) estuaries, b) open-pit, a) incinerators

   ii. soil, groundwater

   iii. food

   iv. air, fire

Terminal Questions

1. **Toxic** refers to the capacity of a substance to produce injury, kill or impair an organism while **hazardous** refers to the probability that injury will result from the use of the substance.
2. i) False ii) True iii) False iv) True v) False vi) False
3. For an effective hazardous waste management system, the following strategy has to be adopted.
   i. Minimisation of hazardous waste generation by using low-waste or nonpolluting technologies.
   ii. The possibility of reusing the generated waste, either as raw material or for recovery of valuable products should be investigated before its ultimate disposal is considered.
   iii. The waste should be detoxified or neutralised through physical, chemical, biological treatment or sludge processing and solidification.
   iv. The unavoidable hazardous waste should be segregated from the nonhazardous ones and collected and stored separately. Finally, the hazardous wastes should be disposed off properly in a secured landfill site.
4. Wastes having chlorine, sulphur, nitrogen and phosphorus contents, polychlorinated biphenyls and those containing heavy metals and carcinogenic substances need special incineration technologies with due precautions.
5. Process wastes such as waste card board can be **reused** in paper industry for making paper pulp. An example of waste **recycle** is as follows. Baghouse dust from scrap steel process can be chemically reacted with waste sulphuric acid to make a useful fertiliser which is technically known as spent pickle liquor.

10.10 FURTHER READING

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Acknowledgement of Figures

1. Fig. 10.2: The richest one we have – our mountains of scrapped cars – offers a rich, inexpensive, and ecologically beneficial resource that can be "mined" for a number of metals.

   (Source: http://image.superstreetonline.com/f/editorials/smog-test-leg)

2. Fig. 10.5: Steps involved in the management of municipal solid waste.

   Source: CPCB Report on Management of Municipal Solid Waste

   (Source: http://image.superstreetonline.com/f/editorials/smog-test-leg)

3. Fig. 10.8: Possible mechanism through which hazardous substances enter the human environment after being disposed off in landfill.

   (Source: https://bawehali.files.wordpress.com/2011/06/landfill.jpg)

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