UNIT 3 LAND POLLUTION

Structure

3.1 INTRODUCTION

Land has been formed by natural geological processes taking place for millions of years. It is one of the most important components of the environment. It is an important source of food and water essential for supporting the life system. Improper use of land, such as deforestation, over cropping, unplanned irrigation and urbanization can result, land pollution and land degradation. Mining and quarrying operations also result in land pollution. Proper land use planning including multiple land use is essential for a sustainable development. Increased population has resulted in abuse of land, which can have long term impact on the quality of environment.

Land pollution is also caused by the indiscriminate waste disposal on land. The contaminants from solid waste, mixed with rain water and industrial liquid waste, percolate through the soil matrix, and pollute both the soil as well as ground water.

Objectives

At the end of this unit you should be able to

- classify solid wastes,
- identify municipal solid wastes, industrial solid wastes, hazardous wastes,
- distinguish between agricultural wastes, insecticides, and pesticides and other residues,
- know about methods of collection and disposal of solid wastes, and
- appreciate the importance of recovery and conversion methods of wastes generated by society and industry.

3.2 SOLID WASTES

Any material that is thrown away (i.e., discarded after some use) constitutes a solid waste. The solid wastes are generated from human and animal activities and under normal circumstances are considered useless. Solid waste disposal is a complex technical and environmental problem of huge dimensions, particularly in modern industrial society. The major categories of solid waste generation are as follows :

(1) municipal wastes,

(2) industrial wastes, and

(3) hazardous wastes.

Improper disposal of solid waste poses a threat to public health. Rodents and insects, sustained by this waste, act as vectors of disease. Moreover some of chemical and industrial wastes are very poisonous, or toxic, or flammable, or radioactive, or possess more than one some such undesirable properties.

Further, improper disposal of such wastes give rise to serious (sometimes irreversible too) environmental damage in terrestrial or aquatic eco-systems. Water pollution can occur due to land burial of solid waste. It may be pointed out that most environmental pollution problems, however, are interrelated in so far as air, water and land quality are concerned (Figure 3.1).

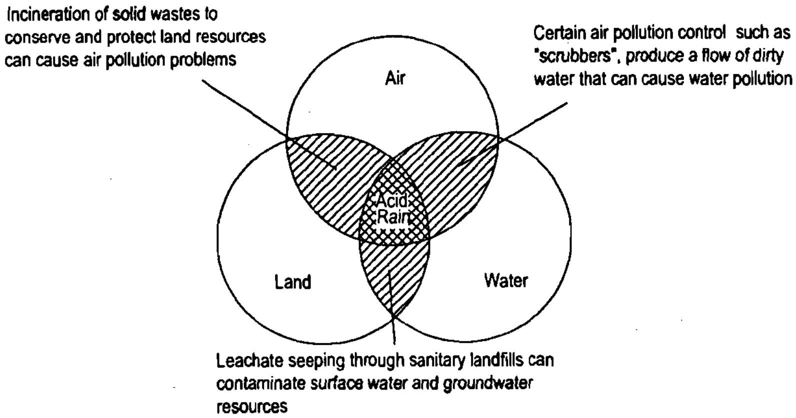


Figure 3.1 : Schematic Representation of Interrelationship of Air, Water, and Land Pollution

3.2.1 Municipal Wastes

The solid wastes from the different zones (or land use areas) of the city are generated that will be differing in their characteristics. These solid wastes comprise *refuse, ordinary refuse* (includes *garbage* and *rubbish*), and *trash*. Refuse, refers to nonhazardous solid waste from the community requiring collection and transporting to processing / disposal site. Garbage comprises items that are highly decomposable (putrescible) food waste – vegetables and meat scraps, while rubbish contains mostly dry, nondecomposable (nonputrescible) material – glass, rubber, tin cans, also, or combustible material – paper, textiles, wooden articles, etc. Trash is formed by that bulky waste material that generally requires special handling, it may not be needed to be collected on a routine bases. Trash includes articles like an old couch, mattress, television, refrigerator, large uprooted tree stump, etc. It must be clear by now that community refuse is aptly referred to as municipal solid waste (MSW).

The major sources and types of solid waste generated in cities are as under :

1)	Residential (Dwelling units)	Food wastes, rubbish consisting of paper, plastics, textiles, glass cans, metals, dust and other materials.
2)	Commercial	Food wastes, rubbish, ashes, abandoned vehicles.
3)	Open area (Streets, parks highways, recreational areas)	Street and road side litter, dead animals, abandoned vehicles etc.
4)	Treatment plant sites, such as, water treatment plants, waste water treatment plants, industrial waste treatment plants.	Mainly different types of sludges from treatment processes. Industrial sludge may be hazardous also.

3.2.2 Industrial Waste

With particular reference to developing countries, like India, industries (processing raw materials into finished products) discard residue into the environment. However, the advanced countries also contribute to this situation, but possess better management techniques, vis-a-vis, these wastes (Figure 3.2).

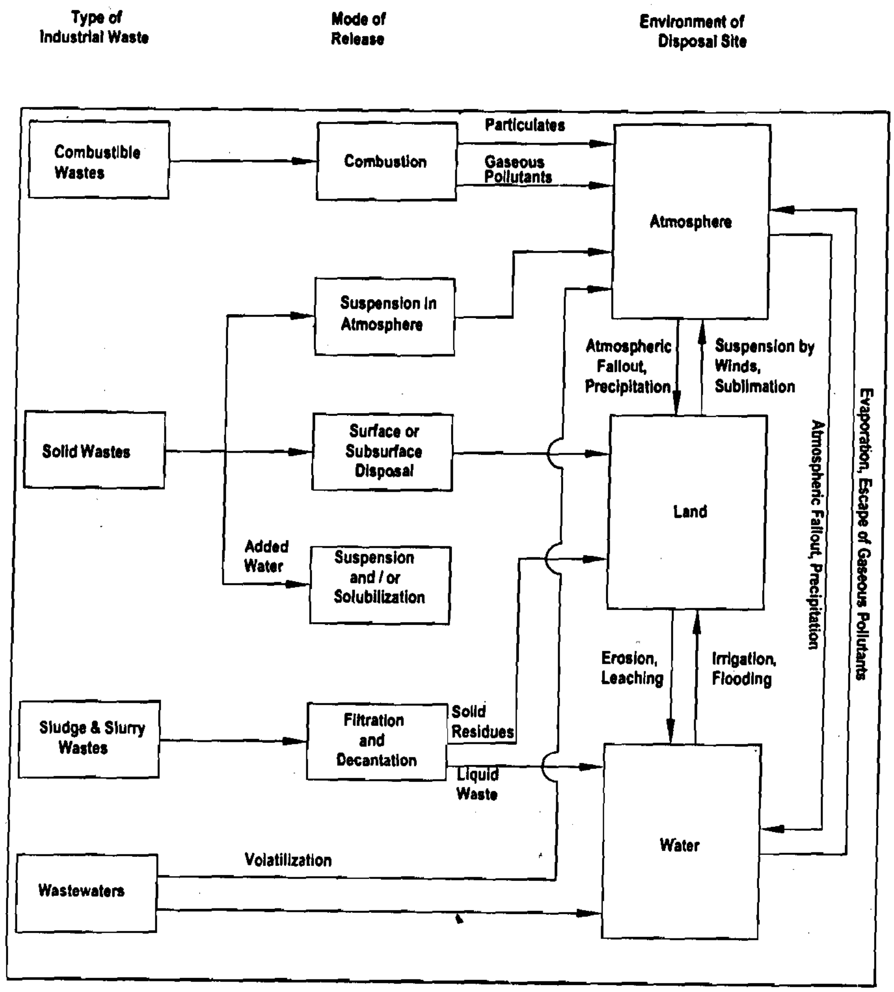


Figure 3.2 : Sources and Modes of Release of Wastes into Environment

Mining, one of the initial contributors to the British industrial revolution, started with coal and metal ores. Later on, with the discovery of petroleum and natural gas deposits, chemical processing also became a component of industrial activity. Carbon-based plastic materials, organic chemicals as pesticides and solvents, and metal-based products characterise industrial production; however, the last items are fundamental to the modern industry. Most of the modern goods (cars to paints) require the use of metals like iron, aluminium, and copper; while less commonly we use such metals and metalloids as lead, cadmium, nickel, mercury, arsenic, and selenium. As such, metallic elements are a part and parcel of industrial wastes; and, they have ill effects on the environment. Most of these substance, are washed out from the atmosphere soon after they enter it, yet, they may remain in the water phase for a long time. Moreover, a bulk of elements are biologically active (i.e., find their place in living organisms). Most of them finally partition (accumulate) into solid phase as aquatic sediments and soils. Some of the elements have the potential to become soluble again and turn bioactive once more.

It is in place to mention that mining and ore processing, drilling for oil and gas and burning coal as fuel generate large volumes of salt-containing wastes. The main substances contained in such wastes include sodium, calcium, sulphate, chloride, and carbonate ions, which are, however, very abundantly found in natural environment. So, as these are not basically hazardous, they do not pose an immediate environmental and health risk. But, what is of concern, is the massive volumes of these wastes generated each year.

Industrial wastes, to sum up, are generated from the industrial activities or manufacturing processes. Depending on the raw materials used and type of manufacturing process, all the three types of wastes, solid, liquid and gaseous are generated. Some of the common industries which generate solid waste along with other wastes on a large scale can be briefly listed as under :

(i) Paper and pulp

(ii) Dyes and intermediates

(iii) Metallurgical industries

(iv) Pesticides/insecticides

(v) Fertilizers

(vi) Plastics

(vii) Refineries

Industrial wastes can be categorised as non-hazardous and hazardous (Figure 3.3). Hazardous wastes obviously have a potential for very deleterions impact on environment and life in general. Fortunately, the bulk of the industrial waste is classified as non-hazardous, and they often possess much lower concentrations of polluting contents compared to hazardous ones.

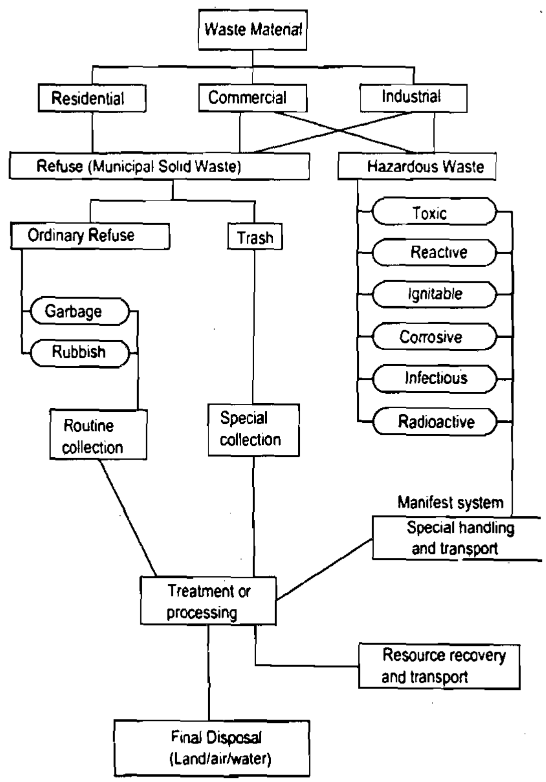


Figure 3.3 : Classification of Solid and Hazardous Waste

3.2.3 Hazardous Waste

There is no precise definition for a hazardous substance, but it is anything which because of its quantity, concentration or characteristics may contribute to increased mortality, illness or hazard to human health and environment if not properly stored, any transported or disposed off.

As per the Resource Conservation and Recovery Act (RCRA), USA, the hazardous waste is one which possesses any one of the four characteristics, such as, *Ignitability*, *Corrosivity*, *Reactivity* or *Toxicity*. In fact, hazardous differ in form as well as behaviour from ordinary solid wastes. They generally are produced in liquid form; however, they can also occur as solids, sludges, or gases. Two more aspects of their basic characteristics include being *infectious* and *radioactive* (Figure 3.3).

Hazardous wastes as mentioned earlier, are generated in very limited amounts at different stages of the concerned manufacturing processes.

Although the words hazardous substance and toxic substance are used interchangeably, toxic substance is harmful or fatal when ingested or absorbed. Thus the word hazardous includes toxic substances also.

The list of industries involving hazardous processes is given in the factories Act, 1948, as amended by the Act No. 20 of 1987. The complete list includes a large number of industries, some of the main ones are given below :

(i) Ferrous, non-ferrous industries,

(ii) Foundries,

(iii) Fertilizer industries,

(iv) Cement industries,

(v) Petroleum industries,

(vi) Chemical industries,

(vii) Dyes and Dyestuff

Similarly, the list of hazardous and toxic chemical has been prepared by the Ministry of Environment and Forests, Govt. of India.

The solid wastes from nuclear power plants containing radioactive substances are of special concern. Because of the technical complexity involved, disposal of radioactive waste is of utmost importance.

3.2.4 Agricultural Wastes

The use of chemical fertilizers and pesticides has considerably increased to enhance agricultural production, mainly the food grains and vegetables. However, the over use of fertilizers has created some environmental problems. The fertilizers enter the human system through the food-web (i.e., the food chain). The run off from the agricultural areas contains nitrogen and phosphorus which ultimately leads to eutrophication of lakes and rivers. The soil structure and fertility is also adversely affected due to excessive use of fertilizers. In addition chemical used in agricultural practice include herbicides insecticides (chlorinated hydrocarbons), fungicides (Cu, Zn, Hg, and organic molecules), acaricides (e.g., Tar oil), and farm manures (e.g., Cu in pig and poultry manures).

Pesticides are resistant to biodegradation and can accumulate to critical levels through biomagnification. The concentration of 8-10 ppm DDT was found in an average American citizen against the permissible level of 7 ppm. DDT remains in environment for a very long duration of about 10 years. Chlordane, another pesticides, remains in environment for more than 12 years.

Thus, it is evident that the agricultural waste is highly potential to cause environmental degradation. The time has come to use biofertilizers and biopesticides which will not have detrimental effects on environment.

Agricultural waste also includes animal waste from feed lots and live-stock yards. The effluent from these sources in the form of slurry is a good source of organic fertilizer. Paddy husk, crop residues, etc. are also included in agricultural wastes.

SAQ 1

Discuss, in general, the composition of municipal and other solid wastes (including industrial and hazardous ones.) Outline the sources that generate this waste while discussing the subject as required above.

SAQ 2

How does agricultural waste pollute the land? Explain in detail giving schematic diagrams.

3.3 SOLID WASTE MANAGEMENT

The solid wastes are continuously generated, and mostly dumped indiscriminately on earth's surface. The assimilative capacity of the environment however is limited; and, hence pollution levels may reach uncontrollable magnitudes. Thus, it is important to install solid waste management system, at the earliest, wherever needed. The following steps constitute a proper solid waste management :

(i) Flow of materials from the point of their production,

(ii) Reduction in the use of raw materials,

(iii) Reduction in the quantity of solid waste,

(iv) Recovery and reuse of materials, and

(v) Energy recovery where possible.

In this regard environmental engineer has to critically examine the following aspects for proper solid waste management.

(i) Waste generation rates and characteristics of the waste from different zones (areas).

(ii) Handling, storage and processing of solid waste near the point of generation.

(iii) Transport of solid waste to the final treatment and disposal sites.

(iv) Treatment for possible recovery of materials/energy and reuse, if feasible.

Actually, problems concerning solid (and even hazardous) waste mataerial are complex and multifaceted. In addition to technical and environmental difficulties that are encountered, there arise administrative, economic and solid tangles that have to be resolved. Addressing all these aspects constitutes the total management of solid and hazardous wastes. Management encompasses planning, design, construction, and operation of facilities for collection, transport, processing and final disposal of the waste material (Figure 3.4).

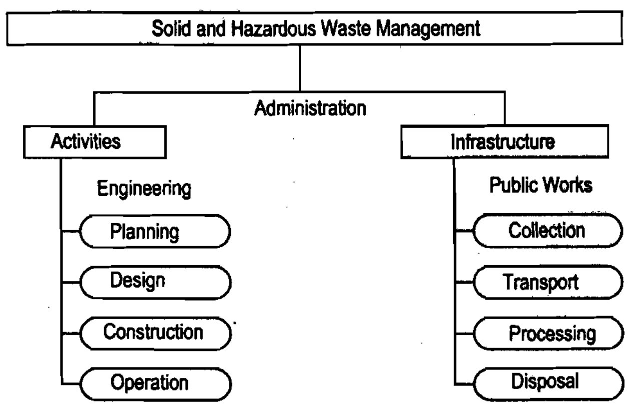


Figure 3.4 : Overall Outline of Solid and Hazardous Waste Management

3.3.1 Quantity of Solid Waste

The quantity and quality of the solid waste generated from developed countries (DCs) and less developed countries (LDCs) are quite different. India is one of the important less developed countries, and solid waste generation varies greatly from city to city and even from different localities of the same city. This is due to the varied economic status of the people in localities. Hazardous wastes from industries and hospitals are also indiscriminately mixed with municipal solid waste creating health hazards. In the recent past health hazards, due to improper solid waste management, in Delhi, Bombay and Surat have been reported.

The average quantity of solid waste generated in the country is about 350-400 gpcd. However depending on the associated commercial activities, the actual quantity may be more. In Bombay it is between 400-425 gpcd. Within the New Delhi Municipal Corporation the waste generation is about 800-1000 gpcd, while for Delhi Municipal Corporation area it is about 300 gpcd. It is estimated that about 50% of the total solid waste generated from cities remains uncollected.

3.3.2 Quantity of Urban Solid Waste

Considering to the solid waste generated from the metropolitan cities of India, like Kanpur, Delhi, Calcutta, Bangalore and Bombay, the composition by average percentage weight is given in Table 3.1.

Table 3.1 : Average Composition of Urban Solid Waste for a Typical Indian City

S. No.	Component	Average Percentage by Weight	Average Percentage by Weight for Typical European City
1.	Paper	3.0	27
2.	Patrescible matter organic matter	55.0	30
3.	Dust, Ash, etc.	24.0	16
4.	Metals	0.5	7
5.	Glass	0.5	11
6.	Textiles	2.0	3
7.	Plastics, Leather Rubbish, etc.	1.0	3
8.	Stones, Wood etc.	14.0	3
	Density	540 kg/m^3	132 kg/m^3

It need not be emphasised that the quantity of solid wastes produced by a given community is related to the standards of living. Side by side industrialisation is contributing the great increase in the amount of refuse generated per capita. It is estimated that a city like Delhi produces about 4000 tonnes/day of solid wastes, while New York generates as much as 25,000 tonnes/day. However, there are seasonal variations too – in India average summer refuse is about 25% higher than the annual average, due to larger consumption of fruits, etc.

In India, paper, cardboard, plastics, rags, etc. are picked up manually by the rag pickers; hence, the quantity of rubbish in India refuse is very small compared to the USA, reducing its calorific value too. However, garbage in USA is very small in quantity, due to use of garbage grinder, and use of tinned and ready made packed food stuffs.

3.4 METHODS OF SOLID WASTE COLLECTION

Regular collection and transport of solid waste are vital operations in any efficient solid waste management and cost about 70-80 per cent of the total cost. It is estimated that about 80% of total cost of solid waste management goes to cover the cost of collection and transport.

The refuse from residential and commercial complexes is delivered to the community storage bins placed at intervals of 50-200 m, depending on the street layout and density of the population. The capacity of the bins may vary from 100 to 500 l, depending on the quantity of waste generated in the respective zones. Appropriate on-site storage has its own importance for residential solid waste that contains a significant quantity of putrescible garbage. Use of containers with tight lids reduces the incidence of rodent and insect infestation; also, it minimises offensive odours and unsightly conditions if containers and storage areas are periodically washed. The contents of these bins are transported to the main bin provided on the road side by means of wheel barrows. The waste from these main bins is collected by transport vehicles daily for final disposal or treatment. Generally, combined collection of garbage and rubbish is more economical than separate collection of each type of waste. Wherever some materials are to be recycled, home owners can practice source separation. – i.e., into paper, glass. etc. House to house collection by civil employees and segregation of organic and inorganic waste by individual housing units can prove to be cost effective method for solid waste management.

Selection of appropriate transport vehicle, especially its size and capacity, type of manual equipment and tools for transferring waste from bins to vehicle, and route for a given transport vehicle are important parameters for optimizing the collection system. Selection of an optimum collection route, particularly for large and densely populated urban areas is based on planning skill and experience. An optimum route is one that contributes to the most efficient use of labour and equipment. Salient features of an optimum route can be outlined as under :

(i) collection paths (or long segments thereof) should not overlap – i.e., avoiding travelling twice down the same street,

(ii) collection of refuse on crowded streets and roads should not occur during rush hours of the day,

(iii) with a view to conserve fuel, collection should preferably take place in the downhill direction,

(iv) it would be ideal if the starting point lies close to the garage for the collection vehicle; and the last collection point be as close as possible to the destination of a filled vehicle – incinerator, processing plant, transfer station, or, say, a sanitary land fill.

Mathematical modelling is a great help in identifying the optimum route within the above mentioned parameters.

However, there are many restrictions imposed on vehicle type and transport route due to the narrow and congested lanes in most of the walled areas of the old cities. Under these circumstances provision of transfer station may be useful. The transfer station receives solid waste from a number of small collection vehicles, which later are transferred to the vehicle for final disposal. When the final disposal/treatment location is far away from the city, transfer stations may prove to be economical.

Modern technology has the potential to ultimately eliminate, in some cases, the procedure of above ground collection and transport of refuse. Pipe-line transport by either hydraulic or pneumatic means may turn economically feasible in selected cases. In hydraulic systems, shredded waste is mixed with water forming a slurry which will flow through underground pipes. But, this system may increase the organic and hydraulic load on existing sewage treatment plants. In a pneumatic sysem, the shredded material is drawn by suction (or vacuum) through the underground pipes to the central processing plant. However, though these systems eliminate the need for noisy and unsightly garbage trucks, the installation costs may be high due to complex control mechanisms, and high speed turbines. Thus, presently these systems are feasible only in specialised local situations.

So far as hazardous wastes are concerned, their storage, collection, as well as transport pose a special challenge because of their potential for serious harm to public health and the environment is the event of any accidental spill. These wastes may be stored at site for varying periods of time in above-ground basins or lagoons – the former even though made of steel or concrete, are subject to corrosion and cracking. Therefore, these facilities are not suitable for storing reactive or ignitable wastes. The commonest type of surface storage consists of an open pit (or holding pond) known as a lagoon. It is desirable that lagoons are lined with impervious clay soil or any synthetic material in order to protect the groundwater. Some hazardous waste can be placed in engineered storage – containerised and buried in a retrievable manner to be finally disposed off when appropriate technology is available in future. High-level radio active wastes, mercury from batteries, and pesticides can be managed by engineered storage.

Relatively, small amounts of hazardous waste, that may be generated intermittently, can be stored in small fiberglass/steel drums, for ease in handling, storing, and transportation. Also, a corrosive material would be stored in fibre glass or glass lined containers to reduce deterioration and leakage. Toxic chemical liquids can be stored in drums (Figure 3.5).

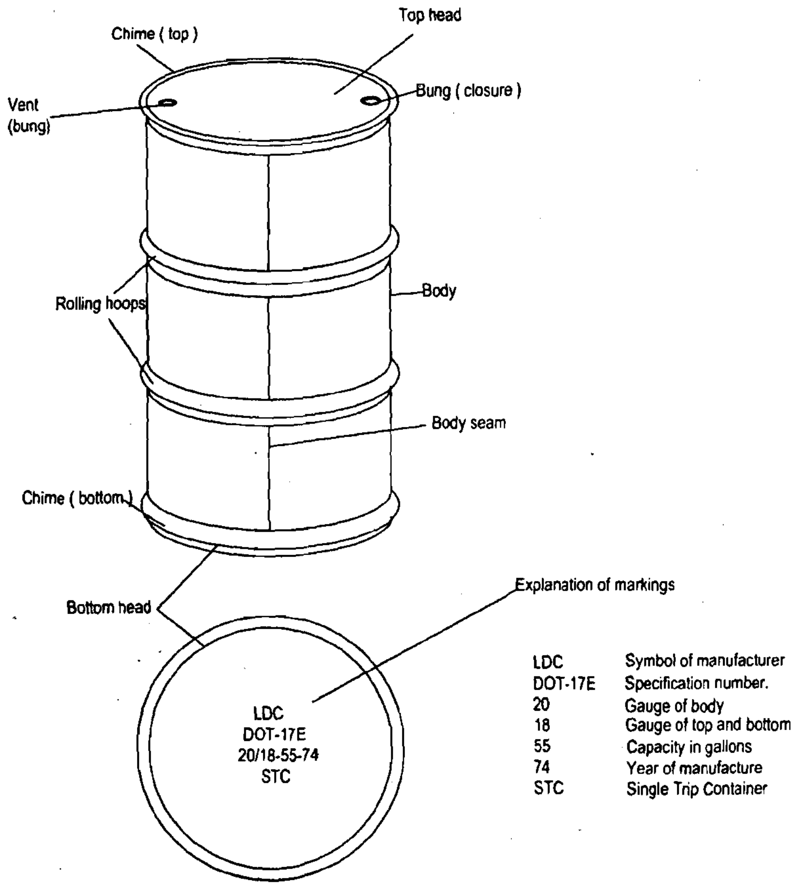


Figure 3.5 : A Typical Closed Head Drum for Storing Toxic Liquids

3.5 DISPOSAL OF SOLID WASTE

Appropriate method of disposal of solid waste is to be chosen with a view not only to satisfy the present need, but also to cater to the future anticipated requirements. Furthermore, it should not result in any environmental pollution -- the prime purpose of waste disposal. The method adopted should preferably be such that it may result in the recovery of material or energy or both.

Waste treatment or processing prior to final disposal has some advantages, such as, reduction of total volume and weight of the waste material. Volume reduction, obviously, helps to conserve land resources – land being the ultimate sink for most of the waste material. Land burial of ashes, etc., is required even after incineration which incidentally reduces the volume to a great degree. Processing changes the form and characteristics of the waste – organic matter is rendered inoffensive, and even useful by composting; and, certain hazardous wastes can either be destroyed, neutralised, or rendered harmless. Moreover, processing helps recover resources and energy.

Most commonly employed methods for solid waste disposal, practiced all over the world are listed as under :

(i) Open dumping,

(ii) Sanitary land fill,

(iii) Composting,

(iv) Shredding, etc.,

(v) Incineration,

(v) Pyrolysis.

The disposal method are to be designed to take care of following items :

(a) Solid wastes which are of no further use,

(b) Residual matter after processing solid waste, and

(c) Residual matter after recovery of by-products or energy.

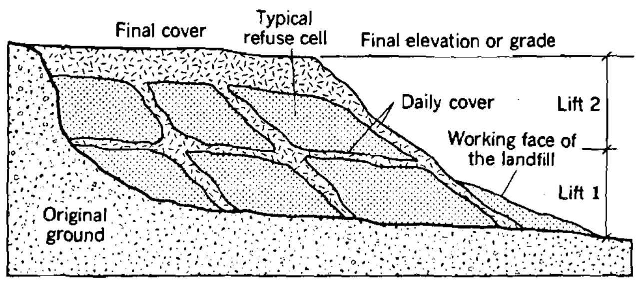
3.5.1 Open Dumping

This practice of solid waste management is the oldest method of disposing solid waste; and it is a very simple, commonly adopted method in this country. The solid waste collected from the city zone is dumped in low lying areas located outside and away from the city. This is not an eco-friendly method and results in contamination of environment. Moreover, it gives unsightly nuisances; therefore, it is not acceptable – open dump areas give out obnoxious smell, and are breeding places for flies and mosquitoes which can spread many diseases and cause eye sores. Burning of solid waste at open dumps, to reduce its volume, creates air pollution. The dwelling areas close to open dump sites are prone to health hazards and poor quality of life.

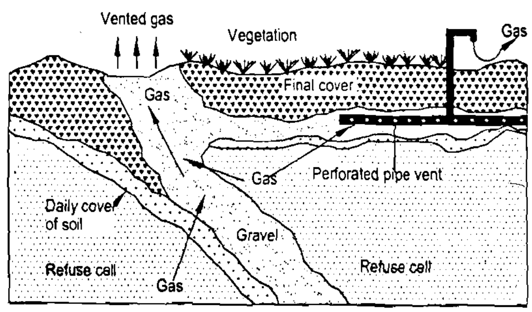
In underdeveloped as well as developing countries this practice is still in practice in semi-urban and rural areas.

3.5.2 Sanitary Landfill

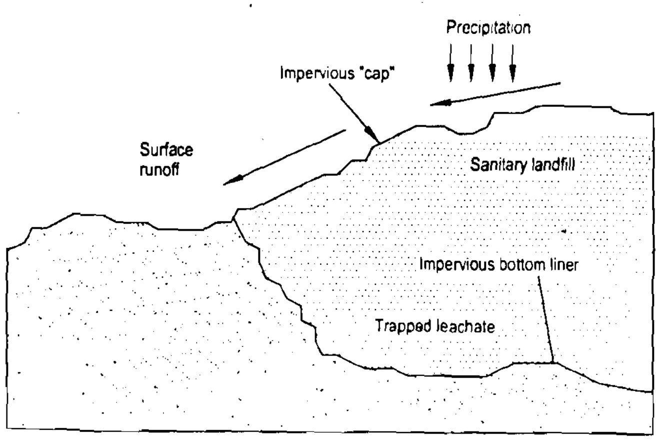
Sanitary landfill, as mentioned above, is an established engineered practice for solid waste disposal on the upper layer of the earth's surface. The refuse is laid and compacted in main layers in the identified areas in trenches or natural depressions. The layered structure is termed a cell and its depth is restricted to about 2 m. The earth layer of about 20 cm thick is provided on the cell (Figure 3.6).



(a) The Basic Building Block (a compacted cell of solid waste) Separated from other Blocks by a Layer of Compacted Soil



(b) Gravel and / or Perforated Pipes to Let Off Methane Gas



(c) Preventing Leachate from Contaminating Surface or Ground Water

Figure 3.6 : Sanitary Landfill (a, b, c)

In sanitary landfill procedure the waste is buried. It is an engineered waste disposal site. Wastes containing high concentrations of metals, that cannot be recycled or recovered economically are also suitable for landfill disposal (may be after some pre-treatment). Similarly, wastes high in salts may also be buried in special landfills, or used as fill materials for road and dam construction. Sanitary landfill is a better technique than the indiscriminate dumping of solid waste on land in its posing no threat to public health and safety, and minimising public nuisances, like wind-blown litter and unpleasent odours.

A landfill may serve it improve / reclaim a poor quality land – it gradually raises the ground level. Completed sanitary landfills can also be converted into community parks, playgrounds, golf courses, etc. In fact it is prudent to keep in mind the ultimate use of the site while designing and operating the project.

In recent years, the practice of landfilling has shown a decline in its popularity as a waste disposal option – it is becoming increasingly difficult to identify suitable sites that lie within economical hauling distances. Also, there a realisation that, in the long run, some environmental damage may occur inspite of best designs, construction, and operation of the site. In addition to gas, sanitary landfill produce a highly contaminated liquid called *leachate*. Mixing of leachate with surface or ground water is most undesirable. Moreover, the fill may suffer from structural instability especially is wet areas.

The possible biological and physical reactions in a landfill, after placing and compacting the refuse layers, are briefly outlined as under :

(i) Biological decay of organic matter both aerobically and anaerobically;

(ii) Chemical stabilization of organic matter;

(iii) Gas generation and liquid movement;

(iv) Production of various organic and inorganic matter;

(v) Settlement caused by subsequent consolidation.

The movement of gas can be controlled by installing vents, constructing barriers or by recovery of gas from landfill areas; and leachate can be prevented from percolating by constructing impervious layers (Figure 3.6).

The following considerations are to be addressed for efficient installation and operation of sanitary landfill sites : land requirement, characteristics of the waste, drainage and seepage facility to be provided, operation plant for filling, and types of equipments.

3.5.3 Composting

One additional way to deal with solid waste is composting by which the organic components of solid waste are biologically decomposed under controlled aerobic conditions. This discomposition produces heat, and human pathogens are destroyed, including many that would otherwise survive by other treatment methods. The resultant product can now be handled safety, stored easily (the original volume of organic part may get reduced by as much as 50 per cent), and readily applied to the land without adverse effects on environment. Therefore, one can say that composting is an engineered biological system.

In this method, plastics, rubber and leather are separated from the solid waste and the remaining organic matter is decomposed aerobically or anaerobically to the end product called compost or humus. The original volume of the organic component may be reduced by as much as 50 per cent. Compost may be used as a soil conditioner as mulch. Important steps involved in the complete composting operation include : sorting and separating (mentioned above), size reduction, digestion, product upgrading, and marketing. Further, it may be pointed out that composting is practised in rural areas to deal with the mixture of night soil and refuse.

The composting methods are broadly classified as manual and mechanical. Two manual composting methods have been developed in India : Indore Process, and Bangalore Process.

For the aerobic decomposition, some of the important general design considerations are given below :

Table 3.2 : Important Design Considerations for Aerobic Decomposition

(a)	Particle Size	Between 25 to 75 mm for optimum results.
(b)	Mixing	Regular mixing or turn over of materials is required for maintaining aerobic conditions.
(c)	Moisture content	About 50-60 percent moisture is essential during composting process.
(d)	Temperature	Temperature between 50-55°C is to be maintained for first few days, and there after between 55-60°C. At temperature > 60°C the biological activities get reduced.
(e)	Carbon-Hydrogen ratio	C :H ratio between 30 and 50 is ideal for efficient aerobic decomposition.
(f)	pH	pH should not be more then 8.5 to prevent lots of nitrogen to appear as NH_3 gas.

Indore Process

This method involves turning of piled up mass, comprising refuse and night soil, to decompose it under aerobic consitions.

Brick lined trenches, 3 m × 3 m and 1 m to 1.5 m deep are prepared. Alternate layers of vegetable waste and night-solid (foul matter) are placed in the trenches. The thickness of each layer may be 7-10 cm to a total depth of 1 to 1.5 m in the trench or, the piling may stand above the ground to form a mount called a *windrow*. The mixture is kept in aerobic condition by regular mixing/turning for about two to three months. The compost is then left without turning for about 4 to 6 weeks, and the compost becomes ready for use. Thus, the complete process takes about 4 months or so.

Bangalore Process

This method is anaerobic in nature; and it does not involve any turning over and related handling of the mass to be composted.

The alternate layers (of refuse and night soil) are placed in trenches of 10 m × 1.5 m and 1.5 m deep as in the case of Indore process. The top is covered by an earth layer of about 1.5 m, and is finally left over for decomposition. The mixture gets decomposed anarobically in about 4-5 months time. This compost contains about 1 to 1.5 per cent N, 1.1 to 1.5 per cent *K*, 1.1 per cent *P* on dry weight basis, and proves to be good fertilizer for the soil. Obviously, this method is cleaner than the Indore method; and, as such is widely adopted by municipalities throughout India.

3.5.4 Mechanical Composting Plants

All the operations like shredding, grinding and separation of wastes are carried out mechanically. The degradation of the organic wastes takes place in a rotating cylinder while it registers change in moisture and air contents. In fact, optimum moisture and air contents are maintained for better results; and also optimum temperature is to be aimed at. Approximately 60 to 70 tonnes of compost can be generated from 100 tonnes of refuse.

There is a good number of mechanical compost plants in India, such as at Ahmedabad, Baroda, Calcutta and Bangalore. However mechanical plants are not very popular in U.S.A.; on the other hand, they are in great demand in many European countries.

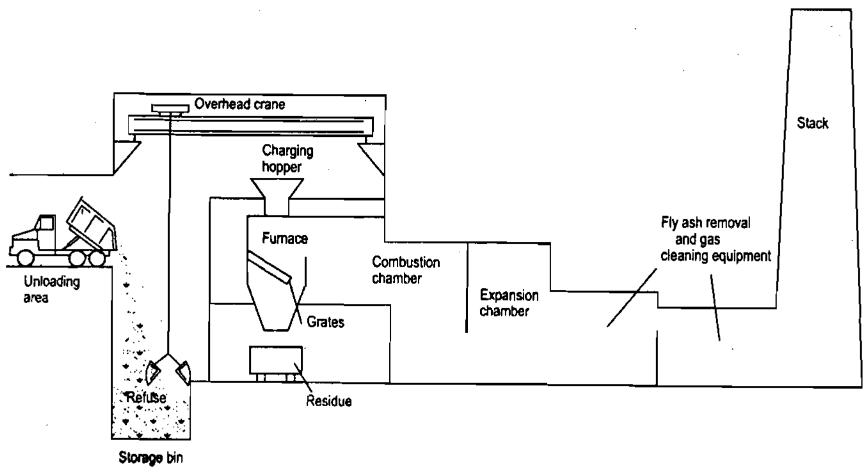
3.5.5 Incineration

One of the most effective methods of reducing the volume and weight of solid waste is to burn it in a well designed furnace – the process is known as incineration. In some instances nearly 25% of the ordinary waste is processed into pallets for burning. However, the process is a bit expensive, and requires air cleaning devices to be put up to control air pollution that may be caused by its exhaust. But, its advantages are many, such as : more than 80% reduction in total volume of the refuse; and is an economical option where land filling is either not viable or not easily available. Sometimes, heat of combustion can be recovered for further use. Incineration may also be used to destroy certain types of hazardous waste materials.

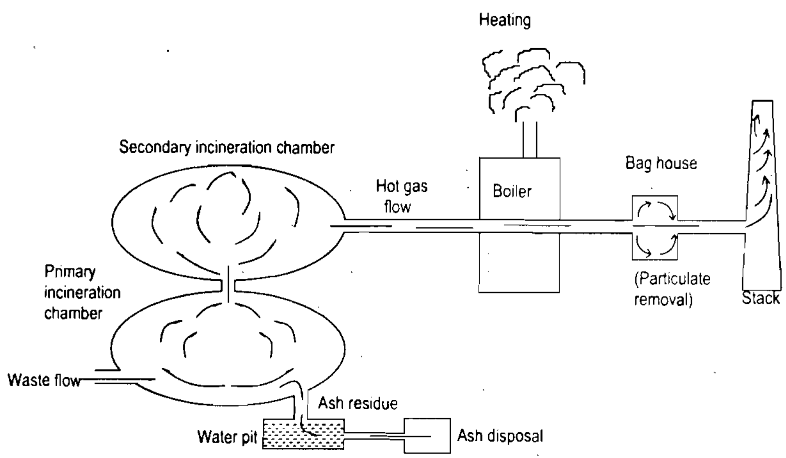
One of the primary problems associated with incineration concerns disposal of its end product, namely, ash, which can contain toxic metals and refractory organics.

Incineration is a high temperature process considered for solid waste treatment especially when the available land (for other modes of waste management) is scarce, disposal requirements are stringent, and destruction of toxic matter is necessary. While achieving about 90 to 95 per cent volume and weight reductions, the incineration process can recover energy through combustion of waste products.

The basic elements comprising overall incineration process are schematically given in Figure 3.7.



(a)



(b)

Figure 3.7 : Schematic Diagram of Process of Incineration

There are mainly two stages involved in the process of incineration – first drying and then combustion. Drying and combustion may be accomplished in separate units or successively in the same unit depending on temperature constrains and control parameters.

Estimation of oxygen (air) requirement and heat balance is very vital for efficient functioning of the incineration process. In practice excess air to the extent of 50-150 per cent is required compared to theoretical computations.

Heat contained in the gases produced due to incineration can be harnessed by obtaining steam through its utilisation. Thus, we can say that heat is converted into steam energy.

The only disadvantage of incineration is its cost of installation and subsequent operation and maintenance. Moreover, there is also a possibility of air pollution due to discharge of particulates and other toxic or noxious emissions from incinerator into the atmosphere, water and land.

3.5.6 Pyrolysis

Another relatively new methodology in municipal solid waste treatment, namely, pyrolysis (also known as destructive distillation) takes recourse to thermal-chemical conversion of matter. It differs from conventional incineration in that it is an *endothermic* process – requiring continuous input of heat energy – while incineration is an exothermic process, i.e., the process gives off heat as oxidation proceeds. Pyrolysis is a high-temperature (1100°C or 2000°F) process taking place in a low-oxygen or no-oxygen atmosphere. The process can become self-sustaining by recycling its by-products. The process also substantially reduces the volume of the solid waste.

Pyrolysis can be particularly useful in converting rubber to fuel oil and combustible gas. In fact, discarded rubber is a troublesome form of solid waste, since it does not compact or decompose.

The process of pyrolysis thus consists in the heating of organic matter in oxygen-free atmosphere which results in its splitting through a combination of thermal cracking and condensation reactions into gaseous, liquid and solid fractions. Thus, pyrolysis is an endothermic reaction (as mentioned above) contrary to incineration which is an exothermic process.

As a result of pyrolysis three major components are generaged, namely :

(i) Gas stream containing gases like H_2, CH_4, CO, CO_2, and other gases depending on the characteristics of the solid waste;

(ii) Tar or oil stream containing chemicals like acitic acid, acetone and methanol; and

(iii) Char containing pure cotton and inert material.

The gas stream contains about 26000 KJ/m^3 of energy, while the pyrolytic oils contain about 23000 KJ/kg of energy. Thus, pyrolysis is also an energy recovery process.

3.5.7 Recovery and Recycle

In modern times our perception of what constitutes waste (i.e., useless and unwanted material) has drastically changed. Ecological-cum-environmental imperatives impel the modern advanced / advancing societies to recover and reuse (or recycle) much of thrown-away material. Moreover, the costs of disposing waste material in an appropriate manner are prohibitive; and, thus, alternative waste management techniques are called for.

The best approach of the problem of waste management requires measures to reduce the total quantity (or volume) of the material. This objective is achieved by recycling – that is, sifting out and reusing those components of the waste that has an economic value for the society. In fact, recovery and reuse of heat energy in incineration, and recovery (or recycling) of organic part of a given solid waste in composting furnish illustrative examples in this context.

Any particular material, meant to be recycled, has to be separated from the bulk of the total assorted (mixed) waste. It may have to be sorted with other material(s) of the same classification. Waste separation can be accomplished either at its point of generation or at the central processing facility – manually or mechanically or by both procedures. The reusable components of the waste can be separated from the mixed refuse on the differing physical characterisitics – size, weight (or density), impact resistance, magnetic properties, or even colour. A typical waste material recovery plant may include a hammer mill (or other shredding device), and air classifier (it removes light-weight material – paper, etc.) in which a compressed air stream carries up the light material leaving behind the heavy material. A cyclone separator helps to concentrate the light material that gets dispressed in the air stream. Further, a magnetic separator can be used (as a component of the plant) to separate out ferrous metal (iron) items from the heavier material left out by the air stream. After magnetic separation (Figure 3.8), the waste may have to be processed further in a rotary drum and trommel screen classifier. This facility works on the basis of different size and density characteristics of the waste components – separating out small dense objects (pieces of glass, stones, bottle caps, etc). Also, vibrating screens too are available to sift out such items. Inertial separator, ballistic separator, and inclined separator – all these devices are also used for the separation of denser articles. Further, a few sophisticated methods, based on the principles of : differential floatation in water, optical sensors, and use of infrared light, have been developed or are under development. Infrared based system monitors the reflected infrared light for the characteristics absorption spectra of different materials; and, thus, things like glass, rubber, paper, plastic, etc. can be identified, and separated from the bulk refuse.

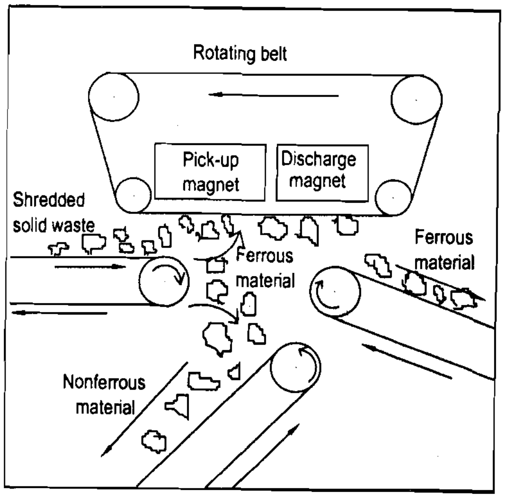


Figure 3.8 : Schematic Representation of a Magnetic Separator

With the improvement in our technology and the changing economic situation, resource recovery and recycling of many solid waste components will become a vogue. It apparently seems that the best way to deal with waste paper (even increasing in weight and volume in developing economics : in US, the municipal solid waste is about 50 per cent paper by weight) would be its recycling. Though recycled paper may find several uses including making of paper boards), it is never as good as new (original) after reprocessing – its fibres are weaker, and the control of its colour is different. Moreover, containers made from it may cause food contamination. Recycling itself may suffer from poor economics – it often costs less to transport raw paper pulp than recycled paper scrap; and collection, sorting, and transport account for about 90 per cent of the cost of recycling. Further, the total process of pulping, deinking and screening waste paper is often more expensive than making paper from virgin wood fibres.

It is, perhaps, erroneously believed that paper recycling will help preserve forests, because it is estimated that about 17 trees go in to produce 1 ton of paper. In fact, selective harvesting of nature trees is a necessary component of a balanced forest management exercise – thinning out or cropping of trees promotes the health and productivity of the timberland.

For the purpose of recycling, metals are classified as ferrous and non-ferrous – steel is a common ferrous metal (and is thus magnetic), while aluminium is a common non-ferrous metal. Gravity, chemical and thermal separation are in use to sift out ferrous and non-ferrous metals. It may be pointed out, here, that so called 'tin cans' are actually made of steel which is coated with tin. This tin coating and the lead solder along the seam of the can do not allow to produce high quality steel after recycling.

One of the most sucessful examples of recovering and reusing a discarded metal is the recycling of aluminium cans. Any impurities in Aluminium scrap – such so iron and magnesium – actually add strength to the recycled product.

A large source of waste metal is constituted by abandoned automobiles. But, the cost of collecting and then transporting old automobiles to shredding or compaction plants is very high. Producing high quality steel from automobile scrap metal is also beset with problems.

Glass is the least troublesome material even though its raw material (primarily silica sand – abundantly available) is readily available, there is still a market for waste glass – producing a new batch of glass, and using as an aggregate material in asphalt pavement under investigation in advanced countries.

Reclaimed rubber has to be shredded and broken down chemically before it is rebonded and remoulded (this process is known as revulcanisation); but this recycled material is not as strong as the original product. Other possible uses are under investigation.

Plastic material is a growing component of our municipal solid waste. It is a nonbiodegradable petroleum–derived item – composed primarily of carbon, hydrogen, and oxygen. Before recycling (involving reheatng, reforming, and reusing) different types of plastic need to be sifted out.

SAQ 3

(a) Give the composition of solid waste in both rural and urban areas of India. What are the methods commonly followed for the disposal of solid waste in these areas?

(b) Write an essay of 200 to 300 words on the management of solid waste.

SAQ 4

Write notes on the following :

(i) Sanitary landfill

(ii) Indore and Bangalore Composting processes.

SAQ 5

Discuss in detail the role and importance of recovery and recycling of the components of solid waste.

3.6 SUMMARY

Land is an important resource, in this hostile cosmic environment (and even on this globe of ours whose three-fourth surface area is watery) on which man, flora and fauna thrive. Its pollution, due to human actions, is indeed suicidal for humanity. Therefore, as one aspect of this proposition, man has to manage the solid waste produced by society with a view to maintain a beneficial environmental regime. Solid waste comprise municipal, industrial, as well as hazardous components.

Hazardous waste is basically defined as a material which because of its quantity, concentration, or characteristics can contribute to increased mortality, illness, and environmental hazard if improperly managed. Agricultural wastes due to use of fertilisers and pesticides also pose a serious problem by entering our food chain.

Methods are available to collect solid waste, properly store it, dispose it off with minimum harm, or to recycle the material if possible. Practices like open dumping, making sanitary landfills, composting, incineration and pyrolysis are employed to deal with community waste according to situation and resources available.

Recycling of metals, rubber, paper, plastics, and glass, etc. are being practised wherever feasible in order to conserve scarce resources as well as with a view to manage the wastes scientifically and optimize the economics of the waste management process.

3.7 ANSWERS TO SAQs

Please refer to the appropriate sections given in the unit, as well as reference material.