MODULE 3 WASTE MANAGEMENT

Unit 1 Wastewater Management
Unit 2 Composition of Solid Wastes

UNIT 1 WASTEWATER TREATMENT

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 How to study this unit
4.0 Main Content
  4.1 Wastewater Characteristics
  4.2 Terminologies in Wastewater Treatment
  4.3 Conventional Wastewater Treatment
    4.3.1 Preliminary Wastewater Treatment
  4.4 Hot Climate Challenges
  4.5 Wastewater Reuse
5.0 Activities
6.0 Assignments
7.0 Summary
8.0 References

1.0 INTRODUCTION

In modern societies, proper management of wastewater is a necessity, not an option. The practice of collecting and treating wastewater prior to disposal is relatively a recent undertaking. It began to gain the attention of the stakeholders only when it became apparent that the "available water" is inadequate to support the available people and their needs. Earlier, city dwellers (of London, Paris and Boston, for example) used to place "night soil" in buckets along the streets and workers would empty the waste into "honey wagon" tanks. The waste was transported to rural areas for disposal over agricultural lands.

The invention of the flush toilet in the 19^{th} century drastically changed waste-disposal practices. Existing systems for transporting urban wastes for disposal on agricultural lands were not adequate to handle the large volume of liquid generated by the flush toilets. Faced with this transportation problem, cities began to use natural drainage systems and storm sewers for wastewater carriage. Since storm drain systems naturally ended at watercourses, the implication of this practice was that waterborne wastes were discharged directly to streams, lakes and estuaries without treatment such that the self-purification capacity of the receiving streams was exceeded and nuisance conditions became intolerable. Gross pollution often resulted and health problems were transferred from the sewered community to downstream users of water.

The first "modern" sewerage system for wastewater carriage was built in Hamburg, Germany in 1842 by Lindley. Lindley's system included many of the principles that are still in use today. Advanced wastewater-treatment processes have been developed and are still being perfected to produce potable water from domestic wastewater.

2.0 OBJECTIVES

At the end of this unit, y should be able to:

- state the characteristics of wastewater
- list and explain terminologies relevant to wastewater treatment processes
- explain the stages involved in conventional wastewater treatment
- state and explain the challenges often encountered in hot climates conventional wastewater treatment.

3.0 HOW TO STUDY THIS UNIT

1. You are expected to read carefully, through this unit at least twice before attempting to answer the self assessment questions or the tutor marked assignments.
2. Do not look at the solution given at the end of the unit until you are satisfied that you have done your best to get all the answers.
3. Share your difficulties with your course mates, facilitators and by consulting other relevant materials particularly the internet.
4. Note that if you follow the instructions you will feel self fulfilled that you have achieved the aim of studying this unit. This should stimulate you to do better.

4.0 MAIN CONTENT

4.1 Wastewater Characteristics

Wastewaters are usually classified as **industrial** wastewater or **municipal** wastewater. Industrial wastewater with characteristics compatible with municipal wastewater is often discharged to the municipal sewers. Many industrial wastewaters require pretreatment to remove non-compatible substances prior to discharge into the municipal system.

Municipal wastewater, having been put to a wide variety of uses, contains a wide variety of contaminants: suspended solids, biodegradable organics, pathogens, nutrients, refractory organics, heavy metals and dissolved inorganic solids. Suspended solids are primarily organic in nature and are composed of some of the more objectionable materials in sewage. Body wastes, food wastes, paper, rags and biological cells form the bulk of suspended solids in wastewater. Suspended solids cause sludge deposits and anaerobic conditions in aquatic environments. Their removal is essential prior to discharge or reuse of wastewater.

Although suspended organic solids are biodegradable through hydrolysis, biodegradable materials in wastewater are usually considered to be soluble organics such as proteins (40 – 60percent), carbohydrates (25 – 50percent) and lipids (~ 10percent). All of these materials contain carbon that can be converted to carbon dioxide biologically thus, exerting an oxygen demand. Proteins also contain nitrogen; thus a nitrogenous oxygen demand is also exerted. The biological oxygen demand (BOD) is used to quantify biodegradable organics.

All forms of waterborne pathogens – bacteria, viruses, protozoa and helminths may be found in domestic wastewater. These organisms are discharged by persons who are infected with the disease and they transmit communicable diseases. Although pathogens causing some of the more exotic diseases may rarely be present, it is a safe assumption that a sufficient number of pathogens are present in all untreated wastewater to represent a substantial health hazard. Fortunately, few of the pathogens survive wastewater treatment in a viable state.

Traditional wastewater-treatment processes are designed to reduce suspended solids, biodegradable organics and pathogens to acceptable levels before disposal. Additional treatment is required to reduce levels of nutrients if the wastewater is to be discharged to a delicate ecosystem. Processes to remove refractory organics and heavy metals and to reduce the levels of dissolved inorganic solids are required where wastewater reuse is anticipated.

4.2 Terminologies in Wastewater Treatment

Unit Operations/Unit Processes: These are methods used for treating municipal wastewaters. Unit operations involve contaminant removal by physical forces while unit processes involve biological and/or chemical reactions. Although unit operations and processes are natural phenomena, they may be initiated, enhanced or controlled by altering the environment in the reactor.

Reactor: This is the vessel or containment structure, along with all of its appurtenances, in which the unit operation or process takes place.

Wastewater-treatment System: This is composed of a combination of unit operations and unit processes designed to reduce certain constituents of wastewater to an acceptable level.

Primary Treatment: The purpose is to remove solid materials (large debris, inorganic solids and organic suspended solids) from the incoming wastewater.

Secondary Treatment: Usually, this consists of biological conversion of dissolved and colloidal organics into biomass that can subsequently be removed by sedimentation.

Tertiary Treatment: This often involves further removal of suspended solids and/or the removal of nutrients from secondary treatment wastewater.

4.3 Conventional Wastewater Treatment

Conventional treatment is the term used to describe the standard method of sewage treatment. It comprises four stages of treatment:

(i) preliminary treatment,
(ii) primary or physical treatment (sedimentation)
(iii) secondary or biological treatment (biofilteration or activated sludge), and
(iv) sludge treatment (anaerobic digestion of the sludges).

4.3.1 Preliminary Wastewater Treatment

This is the first stage of sewage treatment. It deals with the removal of large suspended or floating objects (rags, maize cobs, pieces of wood) and heavy mineral particles (sand and grit). This is necessary to prevent the equipment used in the subsequent stages of treatment from being damaged. Preliminary treatment comprises screening, grit removal and comminution (a common alternative to screening).

Screening: Coarse solids are removed by a series of closely spaced mild steel bars placed across the flow commonly inclined at 60^o. There are hand-raked screens and mechanically raked screens. Screenings are particularly obnoxious both in appearance and content, and should be buried or incinerated or macerated depending on the volume of the screenings.

Grit removal: Grit (detritus) is the heavy inorganic fraction of sewage solids such as road grit, sand, eggshells, ashes, charcoal, glass and pieces of metal. It may also contain some heavy organic matter such as seeds, coffee grounds, yam and plantain peels and so on and so forth. The grit is either used for land fill or disposed of by burial.

Comminution: A comminutor is a self-cleansing shredding machine which cuts up sewage solids as they pass or are pulled through a fine screen which forms the outer periphery of the machine. Comminutors avoid the problems associated with handling and disposal of screenings, and for this reason, they are popular with plant operators.

Sedimentation: Sedimentation is the primary or physical stage of wastewater treatment involving the gravitational separation of suspension into its component solid and liquid phases. The aim is to produce high degrees of both clarification and thickening. Clarification is the removal of solids from the liquid phase and thickening the removal of liquid from the solid or sludge phase. A high degree of clarification is required to reduce the load on the secondary (biological) treatment plant and a high degree of thickening is desirable so that sludge handling and treatment (which usually accounts for 30percent of the total cost of conventional treatment) is minimised.

Biofilteration: Biofilteration (secondary or biological treatment) is a stage in which the liquid effluent (settled sewage) from primary sedimentation tanks is treated in one of two biological reactors – a biofilter or an activated sludge process. The biofilter (also known as the percolating, trickling or biological filter or bacteria bed) is a circular or rectangular bed of coarse aggregate of about 1.8m deep. Settled sewage is distributed over the bed and trickles down over the surface of the aggregate. On these surfaces, a microbial film develops and the bacteria, which constitute most of this film, oxidise the sewage as it flows past. As the sewage is oxidised, the microbial film grows.

Some of the new cells so formed are washed away from the film by the hydraulic action of the sewage. These cells exert a high BOD and must be removed before the effluent is finally discharged. This is achieved in secondary sedimentation tanks (humus tanks). Secondary tanks are basically similar to primary tanks, but without scum-skimming facilities. The clarified effluent is discharged usually to a river and the humus sludge pumped to the sludge pretreatment unit.

Activated Sludge: Activated sludge is the conventional alternative to biofilteration. Settled sewage is led to an aeration tank where oxygen is supplied either by mechanical agitation or by diffused aeration. The bacteria which grow on the settled sewage are removed in a high-rate secondary sedimentation tank. The sludge contains some inert solids, but the main components making up its loose, flocculent structure are living or active bacteria and protozoa, hence the name "activated sludge".

Sludge Treatment: Primary and secondary sludges are most commonly treated together in a two-stage anaerobic digester. The first stage is heated, if necessary, to 30 – 33^{o}C so that digester can proceed more quickly; the methane gas released in the digestion process is commonly used to heat the digester contents. An alternative operating temperature is 50^{o}C which permits rapid digestion of the sludge by thermophilic bacteria. The second stage is a thickener for quiescent solids separation. The supernatant liquor has a BOD_5 of 5000 – 10000 mg/L and is returned to the main works inlet for complete treatment. The digested sludge, in hot climates, is most advantageously placed on drying beds. When dry, it may be sold as fertilizer because the nutrient value of the sludge is beneficial to vegetation and its granular nature may serve as a soil conditioner.

Tertiary wastewater treatment involves the removal of nutrients and additional components so as to restore wastewater to potable quality. It involves nitrogen, phosphorus and solids removal.

4.4 Hot Climate Challenges

Operation and Maintenance: Conventional sewage treatment relies heavily on complex electrical machinery which requires considerable skills in installation, operation and maintenance. This skill, particularly in maintenance, is not readily available in many of the tropical developing countries including Nigeria. Thus, whenever any of the installation is not working satisfactorily or has stopped working, the usual experience is to abandon the entire plant.

Odour: In hot climates, sewage can soon become septic (malodorous) if sufficient oxygen is not made available to prevent the onset of anaerobic conditions. A higher level of odour can thus be expected in hot climates to come from primary sedimentation tanks which are, by their nature, designed for quiescent settling and not turbulent oxygenation.

Insect Nuisance: The microbial film in biofilters is used as a breeding ground by various flies and midges. In a sense, this is beneficial in that the larvae feed on the film and thus help to prevent ponding. However, although none of the species found in filters actually bites humans, their sheer numbers can be a severe nuisance in hot climates. For example, clouds of *Psychoda* flies can effectively stop all human activities in and near a sewage treatment works.

4.5 Wastewater Reuse

Reuse of completely treated wastewater (referred to as reclamation) may be dictated by several circumstances; this complete treatment of wastewater can seldom be justified except in water-scarce areas where some form of reuse is mandatory. In such places, wastewater may constitute a major portion of the available resource. Where delicate ecosystems necessitate stringent effluent requirements, reuse of the wastewater may help to offset the cost of advanced wastewater treatment, or a reuse that will accept a lower level of treatment may obviate the need for the expense of tertiary treatment prior to discharge.

Some of the purposes for which wastewater has been reused include (i) recreational facilities (e.g. swimming and skiing), (ii) industrial water supply (e.g. for cooling processes), (iii) groundwater recharge (e.g. to stabilize groundwater table), (iv) potable water systems (e.g. in pipe-to-pipe recycling or closed loop).

5.0 ACTIVITY

i. Name and characterize the three most significant components of municipal wastewater.
ii. Differentiate between unit operations and unit processes
iii. Describe the components of (a) primary treatment, (b) secondary treatment and (c) tertiary treatment.
iv. What are the major types and sources of grit in municipal wastewaters? Describe the treatment methods used to remove grit.

6.0 SUMMARY

In this unit, you have learnt that:

- Wastewater treatment prevents gross pollution of our environment.
- Wastewater treatment ensures greater availability of water for different purposes in water-scarce areas especially.
- Conventional wastewater treatment comprises of preliminary treatment, sedimentation, biofilteration and sludge treatment.
- Tertiary (advanced) wastewater treatment ensures its use for important purposes such as potability

7.0 ASSIGNMENT

1. List and discuss the uses to which wastewater subjected to tertiary treatment may be put.
2 (a) Describe the common methods used in removing solids from wastewater.
(b) List and discuss the major operations involved in tertiary wastewater treatment.

8.0 REFERENCES

Peavy, H. (1985). *Environmental Engineering*. New York: McGraw-Hill Int. Editions.

Ademoroti, C. (1996). *Environmental Chemistry and Toxicology*. Ibadan: Foludex Press Ltd.

Mara, D. (1978). *Sewage Treatment in Hot Climates*. Chichester: ELBS and John Willey & Sons.

UNIT 2 COMPOSITION OF SOLID WASTES

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 How to study this unit
4 .0 Main Content
4.1 Solid Wastes
4.2 Types and Sources of Solid wastes
4.3 Physical Composition of Solid Wastes
4.4 Chemical Composition of Solid Wastes
4.5 Changes in Solid Waste Composition
4.6 Solid Wastes Management
4.6.1 Collection, Transportation and Storage of Solid Wastes
4.6.2 Waste Disposal and Treatment
5.0 Activities
6.0 Assignments
7.0 Summary
8.0 References

1.0 INTRODUCTION

Effective handling of solid wastes in a finite world (like ours) which is constantly being exposed to threats from pollution effects can only be guaranteed by an adequate understanding of what solid wastes are, their types, sources, composition and the uses to which they may be put. Perhaps the most difficult task facing an environmental scientist is to predict the composition of solid wastes that will be collected now and in the future. The problem is complicated because of the heterogeneous nature of waste materials and the fact that unpredictable externalities can affect the long-term abundance of the individual waste components.

2.0 OBJECTIVES

At the end of this unit you should be able to:

- identify the various types of solid wastes and their sources
- state and discuss the physical and chemical composition of wastes
- name and discuss types of waste management practices available.

3.0 HOW TO STUDY THIS UNIT

1. You are expected to read carefully, through this unit at least twice before attempting to answer the self assessment questions or the tutor marked assignments.
2. Do not look at the solution given at the end of the unit until you are satisfied that you have done your best to get all the answers.
3. Share your difficulties with your course mates, facilitators and by consulting other relevant materials particularly the internet.
4. Note that if you follow the instructions you will feel self fulfilled that you have achieved the aim of studying this unit. This should stimulate you to do better.

4.0 MAIN CONTENT

4.1 Solid Wastes

Solid wastes are all the wastes arising from human and animal activities that are usually solid and discarded as useless or unwanted. The term "solid wastes" encompasses the heterogeneous mass of throw-aways from residences and commercial activities as well as the more homogeneous accumulations of a single industrial activity. Generally, solid wastes are scrap materials or other unwanted surplus substance or any such substance which to be disposed of as being broken, worn out, contaminated or otherwise spoiled.

4.2 Types and Sources of Solid Wastes

Solid wastes are often classified according to the source from which they are generated. Hence, we have municipal waste, industrial wastes, agricultural wastes and hazardous wastes.

Municipal wastes are wastes that are related to land use and zoning. The most difficult source to deal with is open areas because, in these locations the generation of wastes is in a diffuse process. These are mainly wastes from residential and commercial sources such as food wastes, rubbish, ashes, demolition and construction wastes, special waste, and occasionally, hazardous wastes.

Industrial Wastes are those wastes arising from industrial activities and typically these include rubbish, ashes, demolition and construction wastes and special wastes.

Agricultural Wastes are wastes arising from the by-products of agricultural produce.

Hazardous Wastes are wastes that pose a substantial danger immediately or over a period of time to human, animal or plant life. A waste is classified as hazardous if it exhibits any of the following characteristics: (i) ignitability, (ii) corrosivity, (iii) reactivity and (iv) toxicity.

In the past, hazardous wastes were often grouped into the following categories: (i) radioactive substances, (ii) chemicals, (iii) biological wastes, (iv) flammable wastes and (v) explosives. The principal sources of hazardous biological wastes are hospital and biological research facilities.

4.3 Physical Composition of Solid Wastes

Individual components: Typical components of most municipal solid wastes are food wastes, paper, cardboard, plastics, textiles, rubber, leather, garden trimmings, wood, miscellaneous organics, glass, tin cans, ferrous metals, non-ferrous metals, ashes, bricks, etc. These are the readily identifiable ones consistent with component categories of solid wastes.

Particle size: The size of the component materials in solid wastes is of importance in the recovery of materials especially with mechanical means such as trommel screens and magnetic separators. The particle size distribution of solid wastes is such that those from 0.05 – 0.25m (mesh size) are often much more than those of 0.25 – 0.5m and above.

Moisture content: The moisture content of solid wastes is usually expressed as the mass of moisture per unit mass of wet or dry material. That is,

$$\text{Moisture content} = \left(\frac{a-b}{a}\right)x100$$

where a = initial mass of sample as delivered
and b = mass of sample after drying.

To obtain the dry mass, the solid–waste material is dried in an oven at 77^0C for 24 hours. This temperature and time is used to dehydrate the material completely and to limit the vaporisation of volatile materials.

4.4 Chemical Composition of Solid Wastes

Information on the chemical composition of solid wastes is important in evaluating alternative processing and energy recovery options. If solid wastes are to be used as fuel, the four most important properties to be known are:

a. Proximate analysis
   - Moisture (loss at 105^0c for 1 hour)
   - Volatile matter (additional loss on ignition at 950^0c)
   - Ash (residue after burring)
   - Fixed carbon (remainder)

b. Fusing point of ash
c. Ultimate analysis = percent of C, H, O, N, S and ash.
d. Heating value (energy value)

4.5 Changes in Solid Waste Composition

The composition of solid wastes in Nigerian urban centres is determined by a number of factors: type of settlers (low income earners, medium income earners or high income earners), part of the city; period of the year and technological advancement. For example, the percentage of leaves used for wrapping foodstuff has been reducing progressively since mid 1980s while that of used polythene bags is increasing. Likewise, the volume of papers and cans generated as part of solid wastes in an elite settlement is likely going to be greater than that generated in a village as a whole.

The replacements of leaves and papers for "packaging" food products with polythene bags or plastics has its attendant environmental problems. While leaves and papers decay completely within two or three months of contact with soil, polythene bags take infinitely long; period of time to decay. Refuse dumps where such non-biodegradable matters are numerous accumulate into long-lasting enormous heaps in most Nigerian cities. Apart from constituting eye sores, they block streets, damage rivers and cause floods, produce serious stench and constitute tremendous health hazards. The non-free flowing or sticky nature of solid wastes in a refuse dump gives rise to their accumulation on some habitable parts of the soil surface thus impairing the productive capacity of soils. Groundwater are often contaminated (through seepage), by leachate arising from solid wastes dumped on the ground.

4.6 Solid Wastes Management

Solid waste management means the collection, transportation, storage, disposal, treatment, and recycling of waste including the care of the disposal site.

4.6.1 Collection, Transportation and Storage of Solid Wastes

In most houses and market stalls in Nigeria, metal or plastic dustbins are used to collect and temporarily store solid wastes. If the houses are easily accessible to vehicles, door-to-door collection would be done by simply emptying of the dustbins into the vehicles. But in cases where the accessibility is limited, tricycles with carriers are used for the same purpose. Alternatively, household solid wastes are deposited into solid wastes depots located within the community in a place accessible to vehicles. From the depots, sanitary inspectors transport the solid waste in their vehicles to sites where the wastes are further treated. Refuse collection and transportation take up to 75percent of the total expenses for waste disposal in countries like Nigeria.

4.6.2 Waste Disposal and Treatment

Solid waste disposal refers to the final placement or discharge or deposit of waste into a given environment in such a way that it causes little or no harm to the environment. In Nigeria, waste disposal methods have been ineffective and unsatisfactory. Wastes are often dumped indiscriminately along the streets and open spaces; passengers in transit throw wastes at will on the roads and open gutters are carelessly filled up with wastes. Where a depot is used, sanitary inspectors often delay waste collection until when the depots have been over filled.

The mostly used disposal methods are open dumping, sanitary land filling, compositing, incineration and recycling.

4.6.2.1 Open dumping

Open dumping is commonly practiced in many cities in the third world. The refuse is simply disposed of into the nearest open space on land or surface water without any environmental consideration. This method is not environmentally sound or safe because of so many hazards associated with it.

Open dumping encourages the spread of diseases by harbouring the flies and vermin acting as agents of transmission. Some of the communicable diseases associated with dump sites are fly-borne, rodent-borne and mosquito-borne. At times, open dumping is associated with burning of waste, which can cause fire accident and air pollution. Open dumping can cause contamination of surface and ground waters.

Sanitary Landfill

Landfill is one of the most environmentally sound methods of solid waste disposal adopted by many countries of the developed world. Sanitary landfill operations involve depositing solid wastes in natural or man–made depressions or trenches, compacting them into smallest practical volume and covering them with compacted earth or other material. The microbial degradation reaction which occurs in the landfill generates methane gas that can be collected and used as a source of energy.

Modern landfill sites need to be located in impermeable starter or sealed with an appropriate membrane before the wastes are deposited and should have a system for managing the leachate to prevent groundwater surface water pollution.

Composting

Composting involves shredding and separating the putrescible fraction of municipal waste, mixing it with other organic materials and allowing microbial decomposition to take place. Humus eroded from topical soils can be replaced by compost which has good moisture retaining capacity. It is not so easily washed away as chemical fertilizer. Thus, compost helps to improve soil structure and control soil erosion since it is rich in phosphorus, potassium, nitrogen, carbon and sulphure. However, compost may contain high levels of hazardous (heavy) metals which may cause soil surface or ground water pollution.

Incineration

Incineration entails passing the waste through a chamber at a temperature of approximately 1200^0C in an adequate supply of air or oxygen. In the process, all the organic materials (carbohydrates, lipids and proteins including plastics, fibres and woods) will be oxidised to volatile compounds such as CO_2, H_2O, SO_2, NO_2 etc. The residue after the incineration has a volume of about one–tenth of the original solid waste. Hence, incineration is only a system of waste reduction since the residual ash needs to be disposed of carefully afterward in a landfill.

Advantages of incineration are:

1. The heat generated can be harnessed for electricity generation and hearting of the neighbourhood.

2. Incineration reduces the need for additional landfill sites.
3. It can dispose of up to 99.999percent organic wastes. Including chlorinated organic xemobiotics of properly carried out.
4. Pathogens in the waste are effectively eliminated.
5. The ash residue may be recycled and used in the manufacture of cement, as aggregate in concrete, structural elements in road beds and in asphalt road surfacing mixes.

Disadvantages of incineration include:

1. Incineration is relatively expensive.
2. There is a danger of highly toxic pollutants such as polychlorodibenzo-dioxins (PCDDS) and polychlorodibenzonfurans (PCDFs) being synthesized and emitted into the atmospheres.
3. Toxic heavy metals in fly ash from incinerators may constitute direct and detrimental consequences in the immediate environment as they stress up other environmental matrices such as soil, water and the biota.
4. Incineration metals and metalloids such as Se, Hg, As, Sb and Pb may be transported in the air or enriched on gaseous particulates and travel long distances before they are deposited on and or surface of crops where they may be absorbed via the roots to the foliage into the plant. For example, it has been shown that about 90percent of the total plant uptake of Pb is due to deposition from the atmosphere rather than transport from the soil. This implies that atmospheric deposition of metals could pose a significant source of heavy metal inputs to the food chain where background soil levels are even relatively low.

Recycling

Recycling encompasses the full range of waste resources recovery and reuse techniques. This does not only make the waste material harmless, but converts it to another or original useful material. The practice of recycling solid waste is an ancient one with modern improvements. Metal implements were melted down and recast in prehistoric civilizations. In 1972, in Britain, metal scrap was worth 1,250 million pounds. In that year, 60percent of Pb, 36percent of Cu and 32percent of paper used in Britain came from scrap. In Nigeria too, recently more and more people are getting engaged in scavenging business of metals (steel and aluminum particularly), plastics, bottles and so on and so forth. In Cuba, a technology has been developed for collecting, selecting and preparing urban wastes to feed pigs and poultry. The prepared wastes produce between 18 and 22percent protein. From recycling point of view, solid wastes are valuable resources in the wrong places.

Waste products, when effectively managed, can generate biogas (e.g methane), fertilizer, textile materials, paper, crude oil (by thermal depolymerization) and metals (e.g. aluminum).

5.0 ACTIVITY

i. List and explain the characteristics of hazardous wastes.
ii. What are the health problems of refuse dumps in the Nigerian environment?

6.0 SUMMARY

In this unit, you have learnt that:

- Solid wastes encompass the homogenous and heterogeneous mass of throw-aways from residences, commercial centres and industrial locations.
- Solid wastes are divided into municipal, industrial and hazardous wastes.
- Waste disposal management encompasses collection, transportation, storage and methods waste disposal such as open dumping, sanitary land filling, composting, incineration and recycling.

7.0 ASSIGNMENT

1. Assess and discuss two of the methods adopted in yours or a nearby community to handle the menace of solid wastes.
2. Discuss five merits and five demerits of incineration as a method of solid wastes management.

8.0 REFERENCES

Peavy, H., Rowe, D., & Tchobanoglous G. (1985). *Environmental Engineering*. New York: McGraw-Hill Int. Editions.

Harrison, R. (1996). *Pollution: Causes, Effects and Control*. 3rd ed. London: The Royal Soc. of Chemistry.

Alloway, B., & Ayres, D. (1997). *Chemical Principles of Environmental Pollution*. 2nd ed. London: Chapman and Hall.

Ademoroti, C. (1996). *Environmental Chemistry and Toxicology*. Ibadan: Foludex Press Ltd.