COURSE GUIDE

PHS 807
ENVIRONMENTAL HEALTH

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INTRODUCTION

This course, *PHS 807 Environmental Health* is a two-credit unit course. Environmental health is the branch of public health that is concerned with all aspects of the natural and built environment that may affect human health where health is the science, practice and study of a human's well-being and their health and preventing illnesses and human injuries. Activities in the environmental health field aim at limiting the harmful exposures through natural media such as soil, water, air food, etc.

Environmental health can be divided into five fields; environmental epidemiology, toxicology, exposure science, environmental engineering and law. Information from epidemiology, toxicology, and exposure science can be combined to conduct risk assessments for risk factors to determine whether an exposure poses significant risk to human health. This can in turn be used to develop and implement environmental health policy that, for example, regulates chemical emissions, or imposes standards for proper sanitation. Actions of engineering and law can be combined to provide risk management to minimize, monitor and otherwise manage the impact of exposure to protect human health to achieve the objectives of environmental health policy.
This course guide tells you what to expect from reading this course material.

WHAT YOU WILL LEARN IN THIS COURSE

Environmental health is an aspect of public health that links factors in the environment to human health conditions. This field can be approached from different angles all aimed at ensuring that the environment is managed in a way that it does not impact human health adversely. This course will introduce you to the various aspects of environmental health practice, environmental health determinants and risk factors, ethical issues in environmental heal practice and emerging trends.

COURSE AIM

The aim of this course is to provide insight into the field of environmental health for better understanding into the relationship between the environment and human health.

COURSE OBJECTIVES

By the end of this course, you will be able to:

- explain the concept and evolution of environmental health
- discuss the various disciplines in environmental health field
- explain the atmospheric composition, air pollution and effects of air pollution
- discuss water resources, water treatment processes and waterborne diseases
- understand food safety and hygiene principles and tools
- understand vector control methods
- discuss noise pollution and the health effects of noise pollution
- explain the forms of radiation and the health effects of ionizing radiation
- explain the different types of sanitation systems and excreta disposal methods
- explain the housing standards and indicators as well as Nigeria's housing efforts
- explain the term 'hazards' and discuss different types of hazards
- explain the term "ethics" and the general principles of environmental health ethics
- trace the origins of environmental justice and explain the term "environmental justice"
- discuss the environmental laws and legislation in Nigeria
- explain environmental governance
- discuss the consequences and impacts of climate change on human health
- explain possible impacts of bioterrorism and preparedness towards bioterrorism attacks

WORKING THROUGH THIS COURSE

This course has been carefully put together bearing in mind that you might be new to the course. However, efforts have been made to ensure that adequate explanation and illustrations were made to enhance better understanding of the course. You are therefore advised to spend quality time to study this course and ensure that you attend tutorial sessions where you can ask questions and compare your knowledge with that of your course mates.

COURSE MATERIALS

This course comprises of six modules broken down into 19 units. They are as listed below:

i. A course guide
ii. Study units

STUDY UNITS

This course comprises of six modules broken down into 18 units. They are as listed below:

Module 1 Introduction to Environmental Health

Unit 1 Concepts and Definition of terms
Unit 2 Classification of Environmental Health

Module 2 Environmental Health Determinants

Unit 1 Air Quality
Unit 2 Water resources and Quality
Unit 3 Food hygiene and Safety
Unit 4 Vector Control
Unit 5 Noise pollution and Health
Unit 6 Radiation and Health

Module 3 Sanitation and Waste Management

Unit 1 Sanitation and Excreta disposal
Unit 2 Waste management

Module 4 Housing, Recreational and Workplace Health

Unit 1 Housing and Health
Unit 2 Recreational Health
Unit 3 Workplace hazards and health

Module 5 Environmental Health Ethics, Law and Governance

Unit 1 Environmental Health Ethics, Code of conduct and Practice
Unit 2 Environmental health Policy
Unit 3 Environmental Justice, Law and Jurisprudence
Unit 4 Environmental Governance

Module 6 Current Issues in Environmental Health

Unit 1 Climate change
Unit 2 Bioterrorism

Module 1

In Unit 1 you will be taken through basic concept of environmental health. You will learn about the history of environmental health and its driving forces. In Unit 2, you will be taken through the various important classifications of Environmental Health which will introduce you to the whole field of environmental health.

Module 2

In Unit 1, you will learn about the atmosphere, air pollution sources and pollutants as well as health impacts of air pollution. In Unit 2, you will be taken through the different sources of water, water quality indicators, water pollution, water treatment processes and waterborne or water-related diseases. In Unit 3, you will also learn about the food safety and hygiene, Hazard Analysis and Critical Control Points (HACCP) and some food borne pathogens and illnesses. In Unit 4, you will learn about vectors and vector control methods. In Unit 5, you will study noise pollution, sources of noise pollution and its health effects while in Unit 6, you will also study the concept of radiation, types and sources of radiation as well as health effects of radiation.

Module 3

In Unit 1, you will be taken through the various methods of sanitation and excreta disposal as well as the health implications of poor sanitation and excreta disposal. In Unit 2, you will be introduced to both liquid, solid and hazardous waste management methods and their benefits to humans and the environment.

Module 4

In Unit 1, you will be taken through housing standards and policies especially in Nigeria and its importance health. In Unit 3, you will be introduced to the concept of recreational health and their possible impacts on human and environmental health. Finally, in Unit 3, you will be introduced to the study of workplace hazards; how they can be identified, controlled and their impacts on health of workers.

Module 5

In Unit 1, you will be taken through the concept of environmental ethics, code of conduct and practice where you will learn about the ethical concerns surrounding the environmental health practice as well as the local ethical code for environmental health officers. In Unit 2, you will be introduced to environmental health policies both locally and internationally. Unit 3 introduces you to the laws and legislations of environmental health in Nigeria. In Unit 4, you will learn about environmental governance and the role of various levels of governance over environmental concerns.

Module 6

In Unit 1, you will be taken through climate change, its impact on the environment and health effects on humans. Finally, in Unit 2, you will be introduced to bioterrorism which is not very popular but its gaining grounds globally.

TEXT BOOKS AND REFERENCES

The following are list of textbooks, journals and website addresses that can be consulted for further reading:

Frumkin, H. (2005). *Environmental Health From Global to Local.* San Francisco: Jossey-Bass A. Wiley Imprint.

Merson, M.H., Black, R.E. and Mills, A.J. (2006). International Public Health: Diseases, Programs, Systems and Policies. Jones and Bartlett Publishers. Pp 393 – 438.

ASSESSMENT

There are two components of assessment for this course. They are the tutor-marked assignment and the final examination.

TUTOR-MARKED ASSIGNMENT

The Tutor-Marked Assignment **(**TMA) is the continuous assessment component of your course. It accounts for 30 percent of the total score. The TMAs will be given to you by your facilitator and you will return it after you have done the assignment.

FINAL EXAMINATION AND GRADING

The examination concludes the assessment for the course. It constitutes 70 per cent of the whole course. You will be informed of the time for the examination.

SUMMARY

This course intends to provide you with the knowledge of environmental health as an important pillar in public health and provide insight into the links between the environment and human health. We wish you success in this course and hope that you will apply the knowledge gained to manage your environment and improve your health.

MAIN COURSE

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MODULE 1 INTRODUCTION TO ENVIRONMENTAL HEALTH

UNIT 1 CONCEPTS AND DEFINITION OF TERMS

CONTENTS

1.0 INTRODUCTION

The environment consists of all that you find in your surroundings. Of all factors affecting human health, the environment has the greatest impact. There are many characteristics of the environment which include; air, water, food, roads, wastes, vectors, etc. and all these may affect your health and wellbeing. They may determine your risk of developing disease symptoms or even acute and chronic diseases in the near or distant future, as well as the risk that successive generations will suffer from congenital malformations, developmental disabilities and genetic health conditions.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the concept of environmental health
- discuss the evolution of environmental health
- discuss how the concept of environmental health applies to public health.

3.0 MAIN CONTENT

3.1 What is Environmental health?

The environment is defined as the complex of physical, chemical and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival. The World Health Organization in 2005, defined health as; "A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Environmental Health is an interdisciplinary academic field, an area of research, and an arena of applied public health practice. Environmental health is a branch of public health which addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments.

3.2 The Evolution of Environmental Health

Our ancestors confronted other challenges that we would now identify with environmental health. One was food safety; dietary restrictions in ancient Jewish and Islamic law, such as bans on eating pork, presumably evolved from the recognition that certain foods could cause disease. Another challenge was clean water; in the ruins of ancient civilizations from India to Rome, from Greece to Egypt to South America, archeologists have found the remains of water pipes, toilets, and sewage lines, some dating back more than 4,000 years. Another environmental hazard was polluted air; there is evidence in the sinus cavities of ancient cave dwellers of high levels of smoke in their caves, foreshadowing modern indoor air concerns in homes that burn biomass fuels or coal. Still another ancient environmental health challenge, especially in cities, was rodents. European history was changed forever when infestations of rats in fourteenth century cities led to the Black Death.

Modern environmental health further took form during the age of industrialization. With the rapid growth of cities in the seventeenth and eighteenth centuries, "sanitarian" issues rose in importance. Edwin Chadwick (1800–1890) helped reform Britain's Poor Laws. Five years later, following epidemics of typhoid fever and influenza, he was asked by the British government to investigate sanitation. His classic report, *Sanitary Conditions of the Labouring Population* (1842), drew a clear link between living conditions (in particular overcrowded, filthy homes, open cesspools and privies, impure water, and miasmas) and health, and made a strong case for public health reform. The resulting Public Health Act of 1848 created the Central Board of Health, with power to empanel local boards that would oversee street cleaning, trash collection, and water and sewer systems. John Snow (1813–1858) gained immortality in the history of public health for what was essentially an environmental epidemiology study. During an 1854 outbreak of cholera in London, he observed a far higher incidence of disease among people who lived near or drank from the Broad Street pump than among people with other sources of water. He persuaded local authorities to remove the pump handle, and the epidemic in that part of the city soon abated.

The modern field of environmental health dates from the mid-twentieth century, and perhaps no landmark better marks its launch than the 1962 publication of Rachel Carson's *Silent Spring*. *Silent Spring* focused on DDT, an organochlorine pesticide that had seen increasingly wide use since the Second World War. She also made the link to human health, describing how DDT might increase the risk of cancer and birth defects. With the enormous expansion of cancer research, and with effective advocacy by such groups as the American Cancer Society, environmental and occupational carcinogens became a focus of public, scientific, and regulatory attention.

Environmental health policy also emerged rapidly. With the promulgation of environmental laws beginning in the 1960s, legislators at the federal and state levels created agencies and assigned them new regulatory responsibilities. These agencies issued rules that aimed to reduce emissions from smokestacks, drainpipes, and tailpipes; control hazardous wastes; and achieve clean air and water. Although many of these laws were oriented to environmental preservation, the protection of human health was often an explicit rationale as well.

3.3 Driving Forces of Environmental Health

The DPSEEA (Driving forces – Pressures – State – Exposure – Effects – Actions) model which was developed by the World Health Organization is a tool both for analyzing environmental health hazards and for designing indicators useful in decision making. The "driving forces" are the factors that motivate environmental health processes. The driving forces result in "pressures" on the environment, such as the emission of air pollutants. These emissions, in turn, modify the state of the environment, accumulating in the air and combining to form additional pollutants such as ozone. However, this deterioration in the state of the environment does not invariably threaten health; human exposure must occur. In the case of air pollutants, exposure occurs when people are breathing when and where the air quality is low. The hazardous exposure may lead to a variety of health effects, acute or chronic. In the case of air pollutants, these effects may include coughing and wheezing, asthma attacks, heart attacks, and even early death.

Finally, to eliminate or control environmental hazards and protect human health, society may undertake a wide range of "actions", targeted at any of the upstream steps. For example, protecting the public from the effects of air pollution might include encouraging energy conservation to reduce energy demand and designing live-work-play communities to reduce travel demand (addressing driving forces); providing mass transit or bicycle lanes to reduce driving, requiring emissions controls on power plants, or investing in wind turbines to reduce emissions from coal-fired power plants (addressing pressures); requiring low-sulfur fuel (addressing the state of the environment); warning people to stay inside when ozone levels are high (addressing exposures); and providing maintenance asthma medications (addressing health effects). The most effective long-term actions, however, are those that are preventive, aimed at eliminating or reducing the forces that drive the system.

4.0 CONCLUSION

In this unit we have been able to acknowledge that environmental health involves assessing all the factors in the environment and their effects on human health. We have also looked at the environmental health activities from ancient times to modern times as well as a few key players and pioneers in the field of environmental health. Lastly, we have been able to look at forces that drive the environmental health process through the DPSEEA model.

5.0 SUMMARY

In this unit we have learnt that:

- environmental health is a branch of public health which addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments.
- Our ancestors confronted other challenges that we would now identify with environmental health.
- Modern environmental health further took form during the age of industrialization. With the rapid growth of cities in the seventeenth and eighteenth centuries, "sanitarian" issues rose in importance.
- The modern field of environmental health dates from the mid-twentieth century, and perhaps no landmark better marks its launch than the 1962 publication of Rachel Carson's *Silent Spring.*

- Environmental health policy also emerged rapidly. With the promulgation of environmental laws beginning in the 1960s, legislators at the federal and state levels created agencies and assigned them new regulatory responsibilities.
- The DPSEEA (Driving forces – Pressures – State – Exposure – Effects – Actions) model which was developed by the World Health Organization (Figure 1.1) (WHO, Regional Office for Europe, 2004) is a tool both for analyzing environmental health hazards and for designing indicators useful in decision making.

6.0 TUTOR-MARKED ASSIGNMENT

1. Give a concise definition of environmental health.
2. Identify three major environmental health challenges in ancient times.
3. List three persons involved in environmental health in the industrial era.
4. Explain the DPSEEA model.

7.0 REFERENCES/FURTHER READING

Frumkin, H. (2005). Environmental Health from Global to Local. San Francisco: Jossey-Bass A. Wiley Imprint.

Martens, P. and McMichael, A. J. (2002). *Environmental Change, Climate and Health: Issues and Research Methods.* London: Cambridge University Press, 2002.

McMichael, T. (2001). *Human Frontiers, Environments and Disease.* New York: Cambridge University Press, 2001.

World Health Organization, Regional Office for Europe (2004). *Environment and Health Information System: The DPSEEA Model of Health-Environment Interlinks*. [http://www.euro.who.int/EHindicators/Indicators/20030527_2]. 2004.

UNIT 2 CLASSIFICATION OFENVIRONMENTAL HEALTH

CONTENTS

1.0 INTRODUCTION

Five basic disciplines generally contribute to the field of environmental health; environmental epidemiology, environmental toxicology, exposure science, environmental engineering and environmental law. Each of these disciplines contribute to describing or identifying environmental health problems and are usually combined in order to achieve sustainable solutions to the problems. We will take a look at each one of these disciplines in this unit.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss the various disciplines in environmental health field
- discuss each fields peculiarities and points at which they overlap.

3.0 MAIN CONTENT

3.1 Environmental Epidemiology

Environmental epidemiology is concerned with the discovery of the environmental exposures that contributes to or protect against injuries, illnesses, developmental conditions, disabilities, and deaths; and identification of public health and health care actions to manage the risks associated with harmful exposures. Environmental epidemiology studies external factors that affect the incidence, prevalence, and geographic range of health conditions. These factors may be naturally occurring or may be introduced into environments where people live, work, and play.

Environmental exposures can be broadly categorized into those that are proximate (i.e. directly leading health conditions) including chemicals, physical agents and microbiological pathogens, and those that are distal, such as socioeconomic conditions, climate change, and other broad-scale environmental changes. Proximate exposures occur through air, food, water, and skin contact. Distal exposures cause adverse health conditions directly by altering proximate exposures, and indirectly through changes in ecosystems and other support systems for human health.

Environmental epidemiology research can inform risk assessments; development of standards and other risk management activities and estimates of the co-benefits and co-harms of policies designed to reduce global environment change, including policies implemented in other sectors (e.g. food and water) that can affect human health.

3.2 Environmental Toxicology

Environmental toxicology is a multidisciplinary field of science concerned with the study of the harmful effects of various chemical, biological and physical agents on living organisms. Toxicology studies how environmental exposures lead to specific health outcomes, generally in animals, as a means to understand possible health outcomes in humans. Toxicology has the advantage of being able to conduct randomized controlled trials and other experimental studies because they can use animal subjects. An organism can be exposed to toxicants at various stages of its life cycle. Harmful effects of such toxicants can affect an organism and its community by reducing its species diversity and abundance. Such changes in population dynamics affect the ecosystem by reducing its productivity and stability.
There are many sources of environmental toxicity that can lead to the presence of toxicants in our food, water and air. These sources include

organic and inorganic pollutants, pesticides and biological agents, all of which can have harmful effects on living organisms. There can be so called point sources of pollution, for instance the drains from a specific factory but also non-point sources like the rubber from car tires that contain numerous chemicals and heavy metals that are spread in the environment.

3.3 Exposure Science

Exposure science is the study of an organism's (usually human) contact with chemical, physical, biological agents or other health risk (e.g. accidents) occurring in their environments, and advances knowledge of the mechanisms and dynamics of events either causing or preventing adverse health outcomes. Exposure science studies human exposure to environmental contaminants by both identifying and quantifying exposures. Exposure science has the advantage of being able to very accurately quantify exposures to specific chemicals, but it does not generate any information about health outcomes like environmental epidemiology or toxicology.

Exposure science can be used to support environmental epidemiology by better describing environmental exposures that may lead to a particular health outcome, identify common exposures whose health outcomes may be better understood through a toxicology study, or can be used in a risk assessment to determine whether current levels of exposure might exceed recommended levels. Exposure science plays a fundamental role in the development and application of epidemiology, toxicology, and risk assessment. It provides critical information for protecting human and ecosystem health. Exposure science also has the ability to play an effective role in other fields, including environmental regulation, urban, traffic safety and ecosystem planning, and disaster management; in many cases these are untapped opportunities. Exposure science links human and ecologic behavior to environmental processes in such a way that the information generated can be used to mitigate or prevent future adverse exposures.

3.4 Environmental Engineering

Environmental engineering is concerned with the application of scientific and engineering principles for protection of human populations from the effects of adverse environmental factors; protection of environments, both local and global, from potentially deleterious effects of natural and human activities and improvement of environmental quality. Environmental engineering can also be described as a branch of applied science and technology that addresses the issues of energy preservation, protection of assets and control of waste from human and animal activities. Furthermore, it is concerned with finding plausible solutions in the field of public health, such as waterborne diseases, implementing laws which promote adequate sanitation in urban, rural and recreational areas. It involves waste water management, air pollution control, recycling, waste disposal, radiation protection, industrial hygiene, animal agriculture, environmental sustainability, public health and environmental engineering law. It also includes studies on the environmental impact of proposed construction projects.

3.5 Environmental Law

Environmental law includes the network of treaties, statutes, regulations, common and customary laws addressing the effects of human activity on the natural environment. Information from epidemiology, toxicology, and exposure science can be combined to conduct a risk assessment for specific chemicals, mixtures of chemicals or other risk factors to determine whether an exposure poses significant risk to human health (exposure would likely result in the development of pollution-related diseases. This can in turn be used to develop and implement environmental health policy that, for example, regulates chemical emissions, or imposes standards for proper sanitation. Actions of engineering and law can be combined to provide risk management to minimize, monitor, and otherwise manage the impact of exposure to protect human health to achieve the objectives of environmental health policy.

Customary international law is an important source of international environmental law. These are the norms and rules that countries follow as a matter of custom and they are so prevalent that they bind all states in the world. Numerous legally binding international agreements encompass a wide variety of issue-areas, from terrestrial, marine and atmospheric pollution through to wildlife and biodiversity protection. International environmental agreements are generally multilateral treaties. Protocols are subsidiary agreements built from a primary treaty. They exist in many areas of international law but are especially useful in the environmental field, where they may be used to regularly incorporate recent scientific knowledge. They also permit countries to reach agreement on a framework that would be contentious if every detail were to be agreed upon in advance. The most widely known protocol in international environmental law is the Kyoto Protocol, which followed from the United Nations Framework Convention on Climate Change.

4.0 CONCLUSION

In this unit, we have been able to discuss the various disciplines of environmental health. These fields have their differences and areas of similarities but they are all important in making environmental health effective both locally and globally.

5.0 SUMMARY

In this unit we have learnt that:

- Environmental epidemiology studies external factors that affect the incidence, prevalence, and geographic range of health conditions.
- Environmental exposures can be broadly categorized into those that are proximate (i.e. directly leading health conditions) including chemicals, physical agents and microbiological pathogens, and those that are distal, such as socioeconomic conditions, climate change, and other broad-scale environmental changes.
- Environmental toxicology is a multidisciplinary field of science concerned with the study of the harmful effects of various chemical, biological and physical agents on living organisms.
- There are many sources of environmental toxicity that can lead to the presence of toxicants in our food, water and air.
- Exposure science is the study of an organism's (usually human) contact with chemical, physical, biological agents or other health risk occurring in their environments, and advances knowledge of the mechanisms and dynamics of events either causing or preventing adverse health outcomes.
- Exposure science plays a fundamental role in the development and application of epidemiology, toxicology, and risk assessment.
- Environmental engineering is concerned with the application of scientific and engineering principles for protection of human populations from the effects of adverse environmental factors; protection of environments, both local and global, from potentially deleterious effects of natural and human activities and improvement of environmental quality.
- Environmental law includes the network of treaties, statutes, regulations, common and customary laws addressing the effects of human activity on the natural environment.
- Numerous legally binding international agreements encompass a wide variety of issue-areas, from terrestrial, marine and atmospheric pollution through to wildlife and biodiversity protection.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the five disciplines of environmental health.
2. Discuss two disciplines of environmental health.

7.0 REFERENCES/FURTHER READING

Baker, D., Nieuwenhuijsen, M.J., (2008). *Environmental Epidemiology: Study Methods and Application. New York: Oxford University Press. ISBN 978-0-19-852792-3.*

Davis, M. L. and D. A. Cornwell. (2006). Introduction to environmental engineering (4th ed.) McGraw-Hill ISBN 978-0072424119

Lazarus. R. (2004). The Making of Environmental Law (Cambridge Press 2004).

United States National Research Council. (2012). Exposure Science in the 21st Century: A Vision and A Strategy. Applications of Exposure Sciencep.19. doi:10.17226/13507. ISBN 978-0-309-26468-6.

MODULE 2 ENVIRONMENTAL HEALTH DETERMINANTS

UNIT 1 AIR QUALITY

CONTENTS

1.0 INTRODUCTION

Air is vital to life on earth and without it all living will perish. However, human activities have relentlessly polluted it and as a result affected the quality of life for all living things on the planet. If continued, the consequences will be disastrous. In this unit, we will consider the natural atmospheric composition, air pollution and pollutants as well as some health effects of air pollution.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the atmosphere and its composition
- explain the concept of air pollution
- discuss air pollutants, their sources and effects.

3.0 MAIN CONTENT

3.1 The Atmosphere

The three major constituents of air, and therefore of Earth's atmosphere, are nitrogen, oxygen, and argon. Water vapor accounts for roughly 0.25% of the atmosphere by mass. Earth's atmosphere can be divided (called atmospheric stratification) into five main layers. From highest to lowest, the five main layers are:

Exosphere: The exosphere is the outermost layer of Earth's atmosphere (i.e. the upper limit of the atmosphere). It extends from the exobase, which is located at the top of the thermosphere at an altitude of about 700 km above sea level, to about 10,000 km where it merges into the solar wind. This layer is mainly composed of extremely low densities of hydrogen, helium and several heavier molecules including nitrogen, oxygen and carbon dioxide closer to the exobase.

Thermosphere: The thermosphere is the second-highest layer of Earth's atmosphere. It extends from the mesopause (which separates it from the mesosphere) at an altitude of about 80 km up to the thermopause at an altitude range of 500–1000 km. Because the thermopause lies at the lower boundary of the exosphere, it is also referred to as the exobase. The lower part of the thermosphere, from 80 to 550 kilometres above Earth's surface, contains the ionosphere. The temperature of the thermosphere gradually increases with height. The temperature of this layer can rise as high as 1500 °C (2700 °F).

Mesosphere: The mesosphere is the third highest layer of Earth's atmosphere, occupying the region above the stratosphere and below the thermosphere. It extends from the stratopause at an altitude of about 50 km to the mesopause at 80–85 km above sea level. Temperatures drop with increasing altitude to the mesopause that marks the top of this middle layer of the atmosphere. It is the coldest place on Earth and has an average temperature around −85 °C.

Stratosphere: The stratosphere is the second-lowest layer of Earth's atmosphere. It lies above the troposphere and is separated from it by the tropopause. This layer extends from the top of the troposphere at roughly 12 km above Earth's surface to the stratopause at an altitude of about 50 to 55 km.The atmospheric pressure at the top of the stratosphere is roughly 1/1000 the pressure at sea level. It contains the ozone layer, which is the part of Earth's atmosphere that contains relatively high concentrations of that gas. The stratosphere defines a layer in which temperatures rise with increasing altitude. This rise in temperature is caused by the absorption of ultraviolet radiation (UV) radiation from the Sun by the ozone layer, which restricts turbulence and mixing. Although the temperature may be −60 °C at the tropopause, the top of the stratosphere is much warmer, and may be near 0 °C.

Troposphere: The troposphere is the lowest layer of Earth's atmosphere. It extends from Earth's surface to an average height of about 12 km, although this altitude actually varies from about 9 km at the poles to 17 km at the equator, with some variation due to weather. The troposphere is bounded above by the tropopause, a boundary marked in most places by a temperature inversion (i.e. a layer of relatively warm air above a colder one), and in others by a zone which is isothermal with height. Nearly all atmospheric water vapor or moisture is found in the troposphere, so it is the layer where most of Earth's weather takes place.

Within the five principal layers that are largely determined by temperature, several secondary layers may be distinguished by other properties:

- The ozone layer is contained within the stratosphere. In this layer ozone concentrations are about 2 to 8 parts per million. It is mainly located in the lower portion of the stratosphere from about 15–35 km, though the thickness varies seasonally and geographically. About 90% of the ozone in Earth's atmosphere is contained in the stratosphere.
- The ionosphere is a region of the atmosphere that is ionized by solar radiation. During daytime hours, it stretches from 50 to 1,000 km and includes the mesosphere, thermosphere, and parts of the exosphere. It has practical importance because it influences, for example, radio propagation on Earth.

3.2 Air pollution

Air pollution is the presence in or introduction into the air of a substance which has harmful or poisonous effects. Air pollution has long been a contributor to ill health. With the discovery of fire, humans began to pollute both the air in the places they lived and the air outside. As urban areas developed, pollution sources, such as chimneys and industrial processes, became concentrated in those areas, leading to visible and damaging pollution dominated by smoke. The harmful effects of air pollution were recognized early. In “On Air, Water, and Places,” written nearly 2,500 years ago, Hippocrates (1849) noted that people’s health could be affected by the air they breathe and that the quality of the air differed by area.

Air pollution can occur indoors or outdoors (ambient). Indoor air can be contaminated by biological and chemical substances. Biological contaminants include microorganisms (bacteria, viruses and fungi), pet dander etc while chemical pollutants include carbon monoxide from burning of fossil fuels, volatile organic compounds from wood vanishes, carpets etc. Indoor pollutant concentrations are usually higher than ambient concentrations due to enclosure. The ambient concentration of an air pollutant in a particular location depends on many factors, including emissions sources, weather (for example, temperature, wind speed and direction, and precipitation), and land patterns.

Air pollutants may be categorized by source or by physical and chemical characteristics. An air pollutant may be either directly emitted (primary) or formed in the atmosphere through the physical and chemical conversion of precursors (secondary). For example, emissions of carbon monoxide (CO) from car tailpipes are primary emissions; however, ozone, a secondary pollutant, is formed in the atmosphere through the chemical conversion of other pollutants. Another important distinction between air pollution sources is whether the emissions are natural or the result of human activity. Naturally occurring pollutants include biogenic volatile organic compounds (VOCs) from vegetation, pollens, volcanic gases, and dust from deserts.

A further way in which air pollutants differ is in their physical form; they may be gases or particles (small solids or liquids suspended in air). Aerosols are small solid or liquid particles suspended in air. Physical form and chemical characteristics (for example, the solubility of a gas) affect the pollutant's ability to penetrate into the respiratory system. Gaseous pollutants that are highly soluble in water, such as SO_2, are largely removed by the upper airway, whereas less water soluble gases, such as O_3, and particles can penetrate deeper into the lungs.

Some important air pollutants are:

Particulate Matter: Particulate matter (PM) is the term applied to solid or liquid particles suspended in air, regardless of their chemical composition. This pollutant can either be primary or secondary. PM results from the burning of fuel (for example, emissions from power plants), unpaved roads, industry, and wood-burning stoves and from natural sources such as pollen, dust, salt spray, erosion, and mold. Particles are generally categorized according to their size. PM_{10}refers to particles with an aerodynamic diameter of 10 microns or less, $PM_{2.5}$, or fine PM, has an aerodynamic diameter of up to 2.5 microns, and ultrafine particles have a diameter of up to 0.1 microns. Total suspended particles (TSP) refers to almost all particles in the air and is typically measured as PM mass up to particles of about 45 microns in diameter. The size determines how it is transported in the atmosphere, where it is deposited in the environment, and where it is deposited in the respiratory system. Smaller particles are of special health concern because they penetrate more deeply into the lung. Such particles are typically generated through combustion processes.

Sulfur Dioxide: Sulfur oxides are produced from the combustion of sulfur-containing fuels and materials, such as coal and metal ores. Power plants are the main source of SO_2 emissions. Other sources are industrial boilers, trains, ships, and metal processing facilities. Household use of coal can contribute significant amounts of SO_2 as well. Natural sources of SO_2 include volcanoes. SO_2 can be converted to sulfuric acid, and therefore contributes to acid deposition, which harms vegetation, materials, and wildlife.

Case 2-1: Air Pollution in the Niger Delta

Air pollution is one of the major environmental problems confronting the Niger Delta, however there is paucity of information regarding this problem. The Niger Delta is Nigeria's most endowed region in terms of oil mineral reserves and one of the most industrialized after Lagos. The activities of petrochemical industries as well as a wide range of other anthropogenically related activities including biomass combustion, refuse burning and traffic emissions releases tonnes of substances like volatile organic compounds, oxides of carbon, nitrogen, sulphur, particulate matter, heavy metals and other toxic chemicals at high levels; many time exceeding both the national and international guidelines (Ana, 2011).

Nigeria flares more natural gas associated with crude oil extraction than any other country in the world with estimates suggesting that of the 3.5 billion cubic feet of Associated Gas (AG) produced annually, 2.5 billion cubic feet or about 70% is disposed of through flaring (Tawari and Abowei, 2012). Gas flaring releases large amounts of methane (among other gaseous pollutants), which has a high global warming potential.Methane emission during flaring is also accompanied by another major greenhouse gas; carbon dioxide, of which Nigeria was estimated to have emitted more than 34.38 million metric tons of in 2002, accounting for about 50% of all industrial emissions in the country and 30% of the total carbon dioxide emissions. Although flaring in the developed world has seen a decline, in Nigeria it has increased proportionally with increased oil production (Baird, 2010).

Biomass combustion, bush burning and refuse burning are also sources gaseous pollutants and particulate matter in the Niger

Delta. Previous research has shown that the gaseous pollutants from cooking emissions are carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen dioxide, volatile organic compounds and particulate matter. The particulate matter generated is in form of carbon black, sooth and fly ash which are major components of smoke and are most often within the 10µm size range (Ana, 2011).

All these emissions have potentially harmful effects on the health and livelihood of the communities in the Niger Delta due to emissions of a wide range of toxic chemicals. Humans exposed to such substances can suffer from a wide range of cardiopulmonary problems such as asthma, Chronic Obstructive Pulmonary Disease (COPD), chronic bronchitis, leukemia etc. (Tawari and Abowei, 2012).

Nitrogen Oxides: Nitrogen oxides (NO_x) make up a category of highly reactive gases containing nitrogen and oxygen, such as nitrogen dioxide (NO_2) and nitric oxide (NO). These pollutants react in the atmosphere to form additional pollutants and toxic compounds, including nitroarenes. NO_x is produced through combustion, including fossil fuel combustion, when the nitrogen that comprises almost 80 percent of air is oxidized. The sources of NO_x therefore include car and truck engines, electric utilities, and industries. Indoor air pollution can also contribute to NO_2 through kerosene heaters, unvented gas stoves and heaters, and tobacco smoke. Natural sources of NO_x include stratospheric intrusion, biological processes in the soil, forest fires, and lightning, but the principal sources today are power plants and motor vehicles.

Volatile Organic Compounds (VOCs): VOCs are a category of organic chemicals with a high vapor pressure that readily evaporate at normal temperature and pressure. They include benzene, chloroform, formaldehyde, isoprene, methanol, and monoterpenes, along with hundreds of additional compounds. VOCs originate from natural sources including trees; power plants and industrial processes such as those involving chemicals and solvents; and transportation, including motor vehicles and off-road transportation such as aircraft, construction equipment, and lawn mowers. Motor vehicle emissions account for about 75 percent of transportation-related VOC emissions, with most of these emissions originating from the approximately 20 percent of vehicles that are older and poorly maintained.

Ozone: Ozone is present in the troposphere, the lowest atmospheric layer, which extends to approximately 10 to 15 km above the earth's surface, and in the stratosphere, which extends from the troposphere to about 45 to 55 km above the earth's surface. Stratospheric ozone forms the naturally occurring ozone layer that protects the earth's surface from ultraviolet radiation, whereas ozone, sometimes called ground level ozone, is a harmful pollutant. Ozone is a colorless gas and a photochemical oxidant formed through complex, nonlinear chemical reactions involving the precursors VOCs and NO_x in the presence of sunlight. As a result, pollution involving ozone is sometimes referred to as photochemical smog. Concentrations of ozone are highly seasonal, with higher levels appearing during the hotter months; they also show strong diurnal patterns, following sunlight and transportation emissions patterns.

Carbon Monoxide: Carbon monoxide is a colorless, odorless gas formed by incomplete combustion of carbonaceous material, such as gasoline, natural gas, oil, coal, tobacco, and other organic materials. Motor vehicles contribute the majority of CO emissions to outdoor air, and consequently CO concentrations tend to be higher in areas with high traffic density and during times of high traffic volume. Carbon monoxide levels may also be high in congested urban areas with slow-movingtraffic. When CO is inhaled, it binds to hemoglobin, with over 200 times the affinity of oxygen, to form carboxyhemoglobin (COHb). An increased level of COHb reduces the transport of oxygen to tissues and inhibits the release of oxygen.

3.3 Health Effects of Air Pollution

The health consequences of air pollution are wide-ranging, extending from effects on comfort and well-being to respiratory symptoms and even to premature death. Synergistic interactions may produce effects larger than anticipated from studies of the individual pollutants. Air pollution regulatory programs generally provide individual standards for each pollutant, even though the health effects may be related and pollutants may share similar sources.

SO_2 exposure has been associated with reduced lung function, bronchoconstriction (increased airway resistance), respiratory symptoms, hospitalizations due to cardiovascular and respiratory symptoms, eye irritation, adverse pregnancy outcomes, and mortality. Health effects of NO_2 include irritation of the eyes, nose, and throat at higher concentrations, short-term decreases in lung function, and possibly increased respiratory infections and symptoms among children. VOCs are precursors of ozone but also have such independent health effects as irritation of the respiratory tract, headaches, and carcinogenicity. Short-term exposure to ozone for healthy adults has been associated with temporarily decreased lung function, increased airway resistance, and increased respiratory symptoms, such as coughing and wheezing. Health responses to CO include visual impairment, fatigue, decreased dexterity, dizziness, and nausea. Severe neurological damage or mortality can result from extremely high CO levels such as CO poisoning from exposures indoors.

4.0 CONCLUSION

In this unit we have been able to discuss the atmosphere, its components and air pollution. We have also learnt that indoor and outdoor air can be polluted by substances of natural and/or anthropogenic origins. Of importance are particulate matter, nitrogen oxides, sulphur dioxide, carbon monoxide, ground-level ozone and volatile organic compounds. Human exposure to these pollutants especially through the respiratory tract can result in adverse health conditions.

5.0 SUMMARY

In this unit we have learnt that:

- Earth's atmosphere can be divided (called atmospheric stratification) into five main layers.
- Air pollution is the presence in or introduction into the air of a substance which has harmful or poisonous effects. Air pollution has long been a contributor to ill health.
- Air pollution can occur indoors or outdoors (i.e. ambient).
- Air pollutants may be categorized by source or by physical and chemical characteristics. An air pollutant may be either directly emitted (primary) or formed in the atmosphere through the physical and chemical conversion of precursors (secondary).
- A further way in which air pollutants differ is in their physical form; they may be gases or particles (small solids or liquids suspended in air).
- The health consequences of air pollution are wide-ranging, extending from effects on comfort and well-being to respiratory symptoms and even to premature death.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the layers of the atmosphere.
2. What is air pollution?
3. List the six important air pollutants.

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UNIT 2 WATER RESOURCES AND HEALTH

CONTENTS

1.0 INTRODUCTION

The existence of life depends greatly on water. Humans are approximately 60 percent water, and we cannot survive for more than a few days without it. It is therefore not surprising that human culture has been defined by water over the centuries. We only have to look at development of communities along the major river systems of the world to realize how important water is to humans. In this unit, we will consider water sources, its uses, water pollution and treatment as well as waterborne diseases.

2.0 OBJECTIVES

By the end of this Unit, you will be able to:

- discuss water sources and uses
- explain water treatment processes
- discuss waterborne and water-related diseases.

3.0 MAIN CONTENT

3.1 Sources and Uses of Water

3.1.1 Water Sources

Water resources are sources of water that are potentially useful. Uses of waterinclude agricultural, industrial, household, recreational and environ mental activities. The sources include the following;

Surface water: Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and groundwater recharge. Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water loss. Human activities can have a large and sometimes devastating impact on these factors. Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities and velocities by paving areas and channelizing the stream flow.

Under river flow: Throughout the course of a river, the total volume of water transported downstream will often be a combination of the visible free water flow together with a substantial contribution flowing through rocks and sediments that underlie the river and its floodplain called the hyporheic zone. The hyporheic zone often forms a dynamic interface between surface water and groundwater from aquifers, exchanging flow between rivers and aquifers that may be fully charged or depleted.

Groundwater: Groundwater is fresh water located in the subsurface pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between groundwater that is closely associated with surface water and deep groundwater in an aquifer. The natural input to groundwater is seepage from surface water. The natural outputs from groundwater are springs and seepage to the oceans. Humans can also cause groundwater to be "lost" (i.e. become unusable) through pollution. Humans can increase the input to a groundwater source by building reservoirs or detention ponds.

3.1.2 Uses of Water

Some of the uses of water include;

Agricultural: It is estimated that 70% of worldwide water is used for irrigation, with 15-35% of irrigation withdrawals being unsustainable. In some areas of the world, irrigation is necessary to grow any crop at all, in other areas it permits more profitable crops to be grown or enhances crop yield. Aquaculture is a small but growing agricultural use of water. Freshwater commercial fisheries may also be considered as agricultural uses of water, but have generally been assigned a lower priority than irrigation.

Industrial: Major industrial users include hydroelectric dams, thermoelectric power plants, which use water for cooling, ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. It is estimated that 22% of worldwide water is used in industry. Water withdrawal can be very high for certain industries, but consumption is generally much lower than that of agriculture.

Domestic: It is estimated that 8% of worldwide water use is for domestic purposes. These include drinking water, bathing, cooking, toilet flushing, cleaning, laundry and gardening.

Recreational: Recreational water use is usually a very small but growing percentage of total water use. Recreational water use is mostly tied to reservoirs. If a reservoir is kept fuller than it would otherwise be for recreation, then the water retained could be categorized as recreational usage. Release of water from a few reservoirs is also timed to enhance whitewater boating, which also could be considered a recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers.

Environmental: Environment water use is also a very small but growing percentage of total water use. Environmental water usage includes watering of natural or artificial wetlands, artificial lakes intended to create wildlife habitat and water releases from reservoirs timed to help fish spawn, or to restore more natural flow regimes.

3.2 Water Quality

Water quality refers to the chemical, physical and biological properties of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water. Water quality indicators can be physical, chemical and biological.

3.2.1 Physical Indicators

Turbidity: It can be attributed to the presence of organic (human waste, plant materials, etc.) and inorganic (clay, silt, sand,etc.). It affects the aesthetics of the water and can have health implications as well.

Odour and Taste: minerals and metal salts give only taste to water but decomposing organic matter can give both taste and odour to water. These can also have health implications.

Temperature: Weather conditions and industrial activities can affect water temperature. This can have significant impact on the activities of microorganisms and aquatic life as well as the chemical properties of water such as density, gas solubility etc.

Suspended Solids: sources include; human waste, plant materials, clay, silt, san etc. It affects the aesthetics of the water, and can have health implications.

3.2.2 Chemical Indicators

Total Dissolved Solids: these are solids remaining in water after filtration and drying. They are usually composed of minerals, metals and organic materials. These solids can affect taste, color and odour of water along with its impact on human health.

Organic Compounds: sources include oils, fats, sugars, starch, pesticides, alcohols etc. Organics can deplete oxygen in water, destroy aquatic life and can cause adverse health effects such as cancer.

Inorganic Compounds: they are mainly mineral and metal compounds. These compounds pollute water as a result of mining activities. They affect water taste, colour, odour and turbidity. They also have toxic effects on humans at high concentrations e.g. Minamata disease.

Alkalinity: dissolved minerals and addition of substances such as detergents, fertilizers and pesticides can increase water pH. It gives water a non-pleasant taste.

Hardness: it occurs as a result of natural minerals dissolving in groundwater. It causes the excessive use of soap to form lather and precipitation on hardware such as pipes, pots, kettles, etc.

3.2.3 Biological Indicators

The presence of pathogenic microorganisms is shown by some indicator organisms. The presence of these indicator organisms show that pollution has occurred and further points to the type and level of pollution. Typical indicators used are coliform groups. Water can be tested for either fecal coliforms (E. Coli) or total coliforms i.e. fecal coliforms and other coliforms.

3.3 Water Pollution

Chemical Contaminants: A wide variety of chemicals can contaminate water. These contaminants may originate from either point sources or nonpoint sources. A point source is a stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; for example, a pipe, ditch, ship, ore pit. Examples of point source chemical releases include discharges of mercury, solvents, or polychlorinated biphenyls (PCBs) from industrial drainpipes. Non-point sources are diffuse pollution sources (that is, the pollutants do not have a single point of origin or are not introduced into a receiving stream from a specific outlet; for example, they are pollutants carried off the land by storm water). Common nonpoint sources are agriculture, forestry, urban, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets. A major example of a nonpoint source is agricultural runoff containing pesticides and nutrients.

Microbiological Contaminants: A great many pathogenic organisms can be found in water. Like chemical contaminants, biological contaminants can come from point sources such as leaking septic systems or nonpoint sources such as runoff from city streets. Because most biological contaminants result from human or animal wastes, waste treatment practices play a major role in water contamination. Human waste can be discharged directly to receiving waters
through surface water runoff from open defecation sites, a common occurrence in many developing countries, or processed in ways ranging from a simple shallow pit to a larger community sewage system. These latter systems require large volumes of water for efficient operation, so large amounts of wastewater are generated, requiring subsequent treatment before release to receiving waters. Wastewater treatment and discharge can place a heavy burden on receiving waters in terms of pathogens, nutrients, and toxic chemicals. For some river systems,

wastewater makes up the primary flow during dry seasons. Groundwater can also be contaminated with human pathogens from leaking septic systems, contaminated runoff infiltrating wellheads, and seepage from animal feedlots.

3.4 Water Treatment

Water treatment is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from water in order to produce water fit for human consumption and a variety of other purposes, including fulfilling the requirements of medical, pharmacological, chemical and industrial applications. Water treatment is aimed at reducing and eradicating concentration of particulate matter, parasites, bacteria, algae, viruses and fungi. The methods used include physical processes such as filtration and sedimentation; biological processes such as slow sand filters; chemical processes such as flocculation and chlorination and the use of electromagnetic radiation such as ultraviolet light. The standards for drinking water quality are typically set by governments or by international standards. These standards usually include minimum and maximum concentrations of contaminants, depending on the intended purpose of water use.
The processes below are commonly used in water treatment plants;

Pre-treatment: Water is pumped from its source and directed into pipes or holding tanks. To avoid adding contaminants to the water, this physical infrastructure must be made from appropriate materials and constructed so that accidental contamination does not occur. Large debris such as sticks, leaves, rubbish and other large particles is removed from water especially surface water through a process known as screening. Most deep groundwater does not need screening before other treatment steps.

pH adjustment: Pure water has a pH of about 7 (neither alkaline nor acidic). If the water is acidic (lower than 7), lime, soda ash, or sodium hydroxide can be added to raise the pH during water treatment processes. However, if the water is alkaline, acid (carbonic acid, hydrochloric acid or sulfuric acid) may be added to alkaline waters to lower the pH.

Coagulation and flocculation: Coagulation involves the addition of chemicals to water in order to assist in the removal of particles suspended in water. Particles can be inorganic such as clay and silt or natural organic matter. The addition of inorganic coagulants such as aluminum sulfate (known as alum) cause several simultaneous chemical and physical interactions on and among the particles and consequently precipitation of these particles. The precipitates combine into larger particles under natural processes such as Brownian motion and through induced mixing which is sometimes referred to as flocculation.

Sedimentation: From the coagulation and flocculation section, water flows into a clarifier or settling tank. It is a large tank with low water velocities, allowing floc to settle to the bottom. Thus allowing for cleaner water to flow out of the settling tank.

Sludge storage and removal: As particles settle to the bottom of a sedimentation basin, a layer of sludge is formed on the floor of the tank which must be removed and treated.

Filtration: After separating most floc, the water is filtered as the final step to remove remaining suspended particles and unsettled floc. The most common type of filter is a rapid sand filter. Water moves vertically through sand which often has a layer of activated carbon above the sand. The top layer removes organic compounds, which contribute to taste and odour. The space between sand particles is larger than the smallest suspended particles, so simple filtration is not enough. Most particles pass through surface layers but are trapped in pore spaces or adhere to sand particles.

Slow sand filters may be used where there is sufficient land and space, as the water must be passed very slowly through the filters. These filters rely on biological treatment processes for their action rather than physical filtration. The filters are carefully constructed using graded layers of sand, with the coarsest sand, along with some gravel, at the bottom and finest sand at the top. Drains at the base convey treated water away for disinfection. Filtration depends on the development of a thin biological layer, called the zoogleal layer on the surface of the filter.

Membrane filters are also widely used for filtering drinking water. Membrane filters can remove virtually all particles larger than 0.2 μm including *giardia* and *cryptosporidium.* Membrane filters are an effective form of tertiary treatment and are widely used in industry, particularly for beverage preparation (including bottled water).

Disinfection: Water is disinfected to kill any pathogens which pass through the filters and to provide a residual dose of disinfectant to kill or inactivate potentially harmful micro-organisms in the storage and distribution systems. Possible pathogens include viruses and bacteria, including *Salmonella, Cholera, Campylobacter* and *Shigella,* and protozoa, including *Giardia lamblia* and other *cryptosporidia*. The most common disinfection method involves some form of chlorine or its compounds. Chlorine is a strong oxidant that rapidly kills many harmful micro-organisms. Ozone and ultraviolet light can also be used for disinfection. Following the introduction of any chemical disinfecting agent, the water is usually held in temporary storage to allow the disinfecting action to complete.

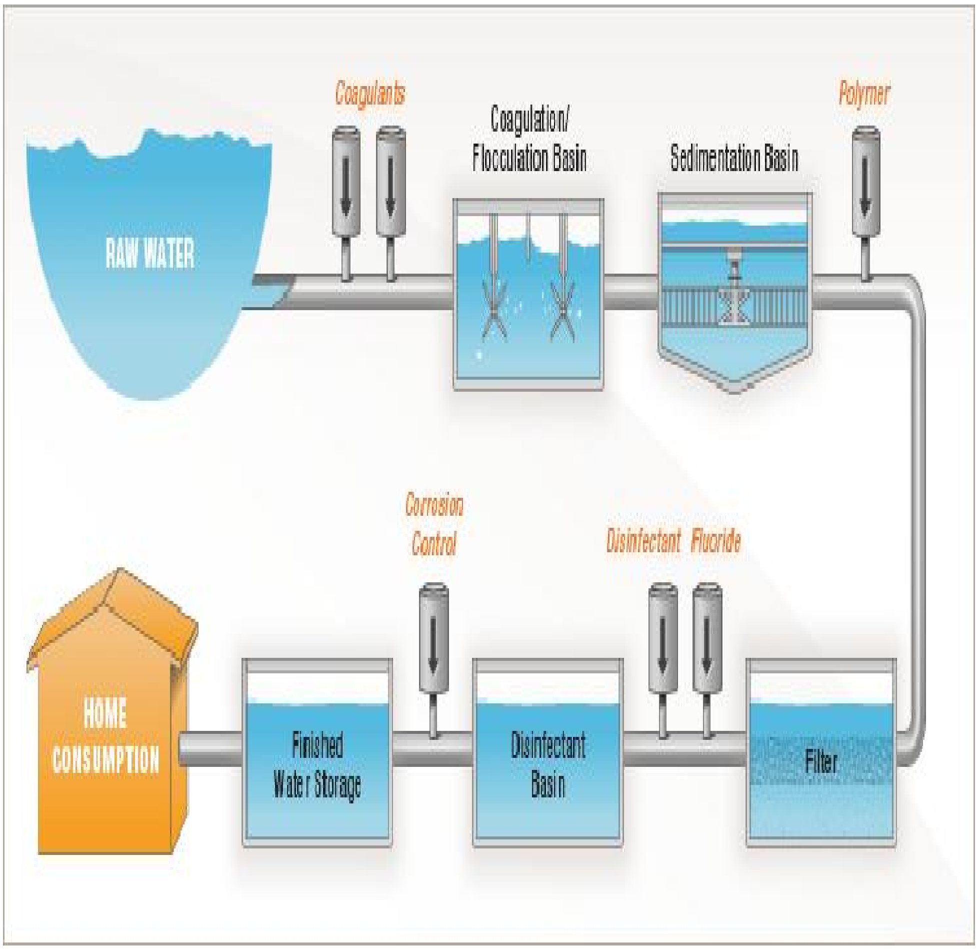

Fig.1: Water Treatment Process

3.5 Waterborne and Water-related Diseases

Waterborne diseases are conditions caused by pathogenic micro-organisms that are transmitted in water. Disease can be spread while bathing, washing or drinking water, or by eating food exposed to infected water. Water-related illnesses fall into four major categories:
Waterborne diseases: they include cholera, typhoid, and dysentery and are caused by drinking water containing infectious viruses or bacteria which often come from human or animal waste.

Water-washed diseases: such as skin and eye infections, are caused by lack of clean water for washing.
Water-based diseases: such as schistosomiasis, are spread by organisms that develop in water and then become human parasites. They are spread

by contaminated water and by eating insufficiently cooked aquatic animals.

Water-related insect vectors: such as mosquitoes, breed in or near water and spread diseases, including dengue and malaria.

4.0 CONCLUSION

In this unit, we have learnt about various water sources, its common uses, different classes of water pollutants, water quality parameters, water treatment processes and waterborne diseases. We have learnt that water is essential to life and human activities can affects its quality. Treatment processes have however been developed in order to make water suitable for use.

5.0 SUMMARY

In this unit we have learnt that:

- Water resources are sources of water that are potentially useful.
- Water resources are sources of water that are potentially useful. Uses of water include agricultural, industrial, household, recreational and enviro nmental activities.
- Water quality refers to the chemical, physical and biological properties of water.
- Water can be polluted by chemical, microbiological and physical contaminants.
- Water treatment is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from water in order to produce water fit for human consumption and a variety of other purposes, including fulfilling the requirements of medical, pharmacological, chemical and industrial applications.
- Waterborne diseases are conditions caused by pathogenic micro-organisms that are transmitted in water.

6.0 TUTOR-MARKED ASSIGNMENT

1. List five water quality indicators.
2. Explain water treatment processes.
3. Explain with examples, waterborne and water-related diseases.

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UNIT 3 FOOD HYGIENE AND SAFETY

CONTENTS

1.0 INTRODUCTION

Food is important to all living things. We source energy from food for all our basic activities. Food can however be a health problem if it carries contaminants such as disease causing pathogens or chemical compounds. These contaminants can be introduced into food at harvest, storage, preparation and distribution. In this unit, we will learn about how to keep food safe and common food borne pathogens.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain food safety and hygiene principles and tools
- identify common foodborne pathogens and toxins.

3.0 MAIN CONTENT

3.1 Concept of Food Safety and Hygiene

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent foodborne illness. This includes a number of routines that should be followed to avoid potential health hazards. In considering industry to market practices, food safety considerations include the origins of food including the practices relating to food labeling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food and guidelines for the management of governmental import and export inspection and certification systems for foods.

Food can transmit pathogens which can result in the illness or death of the person or other animals. The main mediums are bacteria, viruses, mold, and fungus. It can also serve as a growth and reproductive medium for pathogens. In developed countries there are intricate standards for food preparation, whereas in lesser developed countries there are less standards and enforcement of those standards. The five key principles of food hygiene, according to the World Health Organization, are;

1. Prevent contaminating food with pathogens spreading from people, pets, and pests.
2. Separate raw and cooked foods to prevent contaminating the cooked foods.
3. Cook foods for the appropriate length of time and at the appropriate temperature to kill pathogens.
4. Store food at the proper temperature.
5. Do use safe water and safe raw materials.

3.2 Hazard Analysis and Critical Control Points (HACCP)

HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards based on the following seven principles:
Principle 1: Conduct a hazard analysis.
Principle 2: Determine the critical control points (CCPs).
Principle 3: Establish critical limits.
Principle 4: Establish monitoring procedures.
Principle 5: Establish corrective actions.
Principle 6: Establish verification procedures.
Principle 7: Establish record-keeping and documentation procedures.

Conduct a hazard analysis: The purpose of the hazard analysis is to develop a list of hazards which are of such significance that they are reasonably likely to cause injury or illness if not effectively controlled. It is important to consider in the hazard analysis the ingredients and raw materials, each step in the process, product storage and distribution, and final preparation and use by the consumer. A hazard is defined as a biological, chemical or physical agent that is reasonably likely to cause illness or injury in the absence of its control.

The process of conducting a hazard analysis involves two stages. The first stage is known as hazard identification. During this stage, the ingredients used in the product, the activities conducted at each step in the process and the equipment used, the final product and its method of storage and distribution, and the intended use and consumers of the product are reviewed. A list of potential biological, chemical or physical hazards which may be introduced, increased, or controlled at each step in the production process is then developed. After the list of potential hazards is assembled, stage two, the hazard evaluation, is conducted. During this stage, each potential hazard is evaluated based on the severity of the potential hazard and its likely occurrence. In addition, consideration should be given to the effects of short term as well as long term exposure to the potential hazard.

Determine critical control points (CCPs): A critical control point is defined as a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. The potential hazards that are reasonably likely to cause illness or injury in the absence of their control must be addressed in determining CCPs. Critical control points are located at any step where hazards can be either prevented, eliminated, or reduced to acceptable levels. Examples of CCPs may include: thermal processing, chilling, testing ingredients for chemical residues, product formulation control, and testing product for metal contaminants. CCPs must be carefully developed and documented.

Establish critical limits: A critical limit is a maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard. A critical limit is used to distinguish between safe and unsafe operating conditions at a CCP. Each CCP will have one or more control measures to assure that the identified hazards are prevented, eliminated or reduced to acceptable levels. Each control measure has one or more associated critical limits. Critical limits may be based upon factors such as: temperature, time, physical dimensions, humidity, moisture level, water activity (a_w), pH, titratable acidity, salt concentration, available chlorine, viscosity, preservatives, or sensory information such as aroma and visual appearance.

Establish monitoring procedures: Monitoring is a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification. An unsafe food may result if a process is not properly controlled and a deviation occurs. Because of the potentially serious consequences of a critical limit deviation, monitoring procedures must be effective. Ideally, monitoring should be continuous, which is possible with many types of physical and chemical methods.

Establish corrective actions: An important purpose of corrective actions is to prevent foods which may be hazardous from reaching consumers. Where there is a deviation from established critical limits, corrective actions are necessary. Corrective actions should include, determining and correcting the cause of non-compliance; determining the disposition of non-compliant product and recording the corrective actions that have been taken. Specific corrective actions should be developed in advance for each CCP and included in the HACCP plan.

Establish verification procedures: Verification is defined as those activities, other than monitoring, that determine the validity of the HACCP plan and that the system is operating according to the plan. One aspect of verification is evaluating whether the HACCP system is functioning according to the HACCP plan. An effective HACCP system requires little end-product testing, since sufficient validated safeguards are built in early in the process. Therefore, rather than relying on end-product testing, firms should rely on frequent reviews of their HACCP plan, verification that the HACCP plan is being correctly followed, and review of CCP monitoring and corrective action records.

Establish record-keeping and documentation procedures: Generally, the records maintained for the HACCP System should include the following:

1. A summary of the hazard analysis, including the rationale for determining hazards and control measures.
2. The HACCP Plan, Listing of the HACCP team and assigned responsibilities.
3. Description of the food, its distribution, intended use, and consumer.
4. Verified flow diagram.
5. HACCP Plan Summary Table that includes information for:

- Steps in the process that are CCPs
- The hazard(s) of concern.
- Critical limits
- Monitoring procedures
- Corrective actions
- Verification procedures and schedule
- Record-keeping procedures

3.3 Foodborne Diseases

Foodborne illness also known as food poisoning is any illness resulting from direct contact with contaminated food, pathogenic bacteria, viruses, or parasites that contaminate food as well as toxins such as poisonous mushrooms. Symptoms often include vomiting, fever, and aches, and may include diarrhoea. Foodborne illness usually arises from improper handling, preparation, or food storage. Good hygiene practices before, during, and after food preparation can reduce the chances of contracting an illness.

Common foodborne pathogens and toxins include;

Bacteria: Bacteria are a common cause of foodborne illness. Most common bacterial foodborne pathogens are, *Campylobacter jejuni*, *Clostridiumperfringens*, *Salmonella* spp. And*Escherichia coli*.

Viruses: Viral infections make up about one third of cases of food poisoning in developed countries. Foodborne viral infections usually have an incubation period of one to three days. Foodborne viral pathogens include; Enterovirus, Hepatitis A (which is known to have an incubation period of two to six days), Hepatitis E, Norovirus and Rotavirus.

Parasites: Most foodborne parasites are zoonoses. Examples include; Platyhelminthes (*Diphyllobothrium* sp.), Nematodes (*Anisakis* sp.) and Protozoa (*Acanthamoeba* and *Cryptosporidium parvum*).

Natural toxins: Several foods can naturally contain toxins. Some plants may produce toxic substances as a defense mechanism in order to avoid being eaten by animals while animals which are naturally poisonous to eat are rare. Examples include; Mushroom toxins, Shellfish toxin and Tetrodotoxin (fugu fish poisoning).

4.0 CONCLUSION

In this unit, we have learnt that the aim of food safety is to prevent potential hazards and foodborne illnesses and this involves five food hygiene principles. The Hazard Analysis and Critical Control Point plan is aimed at identifying, analyzing, controlling and documenting potential hazards in food processing and it also has seven core principles. Foodborne illnesses can occur as a result of bacterial, viral and parasitic infections. Some natural toxins in some foods can also have adverse health effects on humans.

5.0 SUMMARY

In this unit we have learnt that:

- Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent foodborne illness.
- Food can transmit pathogens which can result in the illness or death of the person or other animals.
- HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards based on the following seven principles.
- Foodborne illness also known as food poisoning is any illness resulting from direct contact with contaminated

food, pathogenic bacteria, viruses, or parasites that contaminate food as well as toxins such as poisonous mushrooms.

- Good hygiene practices before, during, and after food preparation can reduce the chances of contracting an illness.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is food safety and hygiene?
2. Discuss the seven principles of HACCP.

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UNIT 4 VECTOR CONTROL

CONTENTS

1.0 INTRODUCTION

Disease outbreaks can be attributed to many factors, one of which are disease vectors. They can be insects or rodents and because they migrate easily and find their way into human settlements they pose great threats to public health. As such there have been targeted efforts at mitigating or eradicating these disease carrying organisms. In this unit, we will learn about various methods of controlling disease vectors.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- identify various vectors and some of the diseases they cause.
- discuss vector control methods
- discuss Integrated Vector Management.

3.0 MAIN CONTENT

3.1 Vectors

Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans. Many of these vectors are bloodsucking insects, which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later inject it into a new host during their subsequent blood meal. Mosquitoes are the best known disease vector. Others include ticks, flies, sandflies, fleas, triatomine bugs and some freshwater aquatic snails.
Some vectors and the disease they cause are the following;

- Mosquitoes: Chikungunya, Dengue fever, Lymphatic filariasis, Rift Valley fever, Yellow fever, Zika, Malaria, Japanese encephalitis, West Nile fever.
- Sandflies: Leishmaniasis, Sandfly fever (phelebotomus fever)
- Ticks: Crimean-Congo haemorrhagic fever, Lyme disease, Relapsing fever (borreliosis), Rickettsial diseases (spotted fever and Q fever), Tick-borne encephalitis, Tularaemia, Triatomine bugs, Chagas disease (American trypanosomiasis)
- Tsetse flies: Sleeping sickness (African trypanosomiasis)
- Fleas: Plague (transmitted by fleas from rats to humans), Rickettsiosis
- Black flies: Onchocerciasis (river blindness)
- Aquatic snails: Schistosomiasis (bilharziasis)
- Lice: Typhus and louse-borne relapsing fever
- Rats: leptospirosis, plague.

3.2 Vector Control

Vector control is any method to limit or eradicate vectors which transmit disease pathogens. Several of the "neglected tropical diseases" are spread by such vectors. As the impacts of disease and virus are devastating, the need to control the vectors in which they carried is prioritized. Vector control in many developing countries can have tremendous impacts as it increases mortality rates, especially among infants. Due to ease of migration among populations, disease spread is also a greater issue in these areas. Vector control focuses on utilizing preventative methods to control or eliminate vector populations. Common preventative measures are:

Habitat and environmental control: Removing or reducing areas where vectors can easily breed can help limit their growth. For example, stagnant water removal, destruction of old tires and cans which serve as mosquito breeding environments, and good management of used water can reduce areas of excessive vector incidence. Further examples for environmental control is by reducing the prevalence of open defecation or improving the designs and maintenance of pit latrines. This can reduce the incidence of flies acting as vectors to spread diseases via their contact with faeces of infected people.

Reducing contact: Limiting exposure to insects or animals that are known disease vectors can reduce infection risks significantly. For example, insecticide treated nets, window screens on homes, or protective clothing can help reduce the likelihood of contact with vectors. To be effective this requires education and promotion of methods among the population to raise the awareness of vector threats.

Chemical control:

Insecticides, larvicides, rodenticides, Lethalovitraps and repellents can be used to control vectors. For example, larvicides can be used in mosquito breeding zones; insecticides can be applied to house walls or bed nets, and use of personal repellents can reduce incidence of insect bites and thus infection. The use of pesticides for vector control is promoted by the World Health Organization (WHO) and has proven to be highly effective.

Biological control: The use of natural vector predators, such as bacterial toxins or botanical compounds, can help control vector populations. Using fish that eat mosquito larvae or reducing breeding rates by introducing sterilized male tsetse flies have been shown to control vector populations and reduce infection risks.

3.3 Integrated Vector Management (IVM)

Integrated Vector Management is a rational decision-making process for the optimal use of resources for vector control. The approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control. The ultimate goal is to prevent the transmission of vector-borne diseases such as malaria, dengue, Japanese encephalitis, leishmaniasis, schistosomiasis and Chagas disease.

Driving forces behind a growing interest in IVM include the need to overcome challenges experienced with conventional single-intervention approaches to vector control as well as recent opportunities for promoting multi-sectoral approaches to human health. The Global Strategic Framework for IVM notes that IVM requires the establishment of principles, decision-making criteria and procedures, together with timeframes and targets. The Framework identifies the following as five key elements for the successful implementation of IVM:

- Advocacy, social mobilization, regulatory control for public health and empowerment of communities.
- Collaboration within the health sector and with other sectors through the optimal use of resources, planning, monitoring and decision-making.
- Integration of non-chemical and chemical vector control methods, and integration with other disease control measures.
- Evidence-based decision making guided by operational research and entomological and epidemiological surveillance and evaluation.

- Development of adequate human resources, training and career structures at national and local level to promote capacity building and manage IVM programmes;

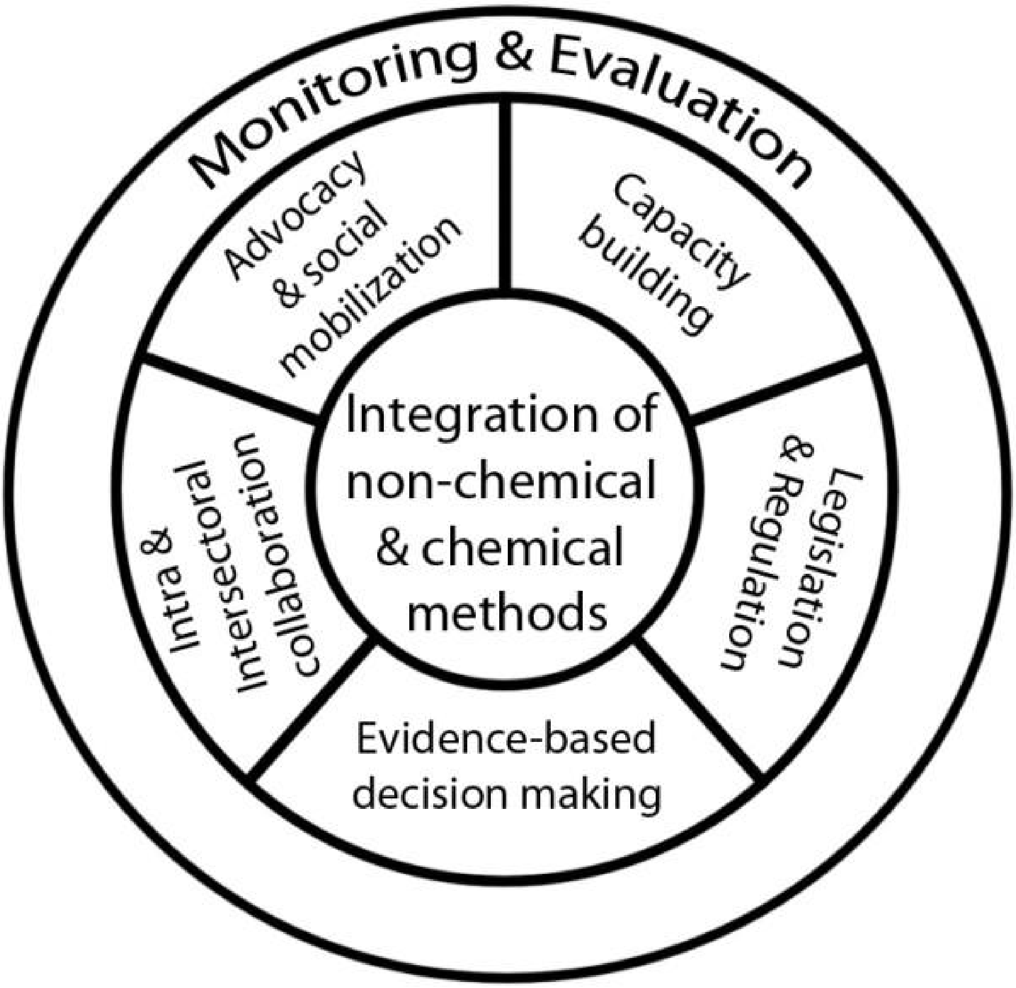

Fig 2: An Integrated Vector Management Chart

4.0 CONCLUSION

Vectors are organisms that spread disease pathogens. There are various methods of controlling them. Some of which include environmental, biological and chemical controls as well as the integrated vector management strategy. These approaches will greatly reduce or eradicate disease vectors and consequently improve health among populations.

5.0 SUMMARY

In this unit we have learnt that:

- Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans.

- Mosquitoes are the best known disease vector. Others include ticks, flies, sandflies, fleas, triatomine bugs and some freshwater aquatic snails.
- Vector control is any method to limit or eradicate vectors which transmit disease pathogens.
- Removing or reducing areas where vectors can easily breed can help limit their growth.
- : Limiting exposure to insects or animals that are known disease vectors can reduce infection risks significantly.
- Insecticides, larvicides, rodenticides, Lethalovitraps and repellents can be used to control vectors.
- The use of natural vector predators, such as bacterial toxins or botanical compounds, can help control vector populations.
- Integrated Vector Management is a rational decision-making process for the optimal use of resources for vector control. The approach seeks to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease-vector control.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are vectors?
2. Explain the methods of vector controls.
3. Discuss Integrated Vector Management.

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UNIT 5 NOISE AND HEALTH

CONTENTS

1.0 INTRODUCTION

Many people experience noise from numerous sources. Moving cars, machines at the workplace, domestic activities etc. This can affect the quality of life and could even contribute to serious health problems. In this unit, we will consider the various sources of noise pollution and the adverse health effects on humans.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss noise pollution
- discuss the health effects of noise pollution.

3.0 MAIN CONTENT

3.1 Concept of Noise

Noise is unwanted sound appraised to be unpleasant, loud or disruptive to hearing. Sound is measured based on the amplitude and frequency of a sound wave. The energy in a sound wave is measured in decibels (dB) which is the measure of loudness or intensity of a sound. On the other hand, pitch describes the frequency of a sound and is measured in hertz (Hz). Environmental noise is the accumulation of all noise present in a specified environment. The principal sources of environmental noise are surface motor vehicles, aircraft, trains and industrial sources. These noise sources expose individuals to noise pollution that creates not only annoyance, but also significant health consequences such as elevated incidence of hearing loss and cardiovascular disease. Environmental noise is however, governed by laws and standards which set maximum recommended levels of noise for specific land uses, such as residential areas, areas of outstanding natural beauty, or schools.

3.2 Noise Pollution

Noise pollution is the presence of disturbing noise with harmful impact on the activity of human or animal life. Outdoor noise generally is mainly caused by machines, transportation systems, motor vehicles engines and trains. Outdoor noise can also be attributed to poor urban planning whereby industries are located in residential areas. Traffic noise can be reduced by the use of noise barriers, limitation of vehicle speeds, alteration of roadway surface texture, limitation of heavy vehicles, use of traffic controls that smooth vehicle flow to reduce braking and acceleration, and tire design. Aircraft noise can be reduced by using quieter jet engines. Industrial noise can be addressed by redesigning industrial equipment, shock mounted assemblies and use of physical barriers in the workplace.

3.3 Health Effects of Noise Pollution

Noise pollution affects both health and behavior. Noise can damage psychological and physiological health. Noise pollution can cause hypertension, high stress levels, tinnitus, noise induced hearing loss, sleep disturbances, and other harmful effects. High noise levels can result in cardiovascular effects and exposure to moderately high levels can result in a rise in blood pressure and an increase in stress, as well as to increased incidence of coronary artery disease.

Case 2-6: Noise Pollution in South Eastern Nigeria

There are very few reports of noise pollution studies in Nigeria. In 2004, Anomohanran *et al.*,reported that the noise situation in Agbor is caused by the presence of big trucks, luxurious buses and by commercial activities while studying noise levels in Agbor city, Delta Stateand they recommended thatthe government restrict the establishment of schools and hospitals along major highways because of the high noise levels observed from this location. Onuu (1999) also corroborated Anomohanran *et al.*,findings that road traffic noise constitutes the largest proportion of environmental noise in Urban areas in Nigeria and recommended that priority in any noise abatement programme be given to road traffic noise.

According to Ochsner (2003), both the amount of noise and the length of time one is exposed to noise determine its ability to damage hearing. Hearing loss often occurs gradually, becoming worse over time. Therefore, many people do not become aware of their hearing loss until it is too late to avoid permanent damage.

4.0 CONCLUSION

Noise is unwanted sound judged to be unpleasant, loud or disruptive to hearing. Traffic and Industries are common sources of noise globally. These noise pollutants can be combated through urban planning and technological innovations. Exposure to noise can pose serious health challenges such as hearing loss and cardiovascular diseases.

5.0 SUMMARY

In this unit we have learnt that:

- Noise is unwanted sound appraised to be unpleasant, loud or disruptive to hearing.
- Environmental noise is the accumulation of all noise present in a specified environment.
- Noise pollution is the presence of disturbing noise with harmful impact on the activity of human or animal life.
- Outdoor noise generally is mainly caused by machines, transportation systems, motor vehicles engines and trains.
- Noise pollution can cause hypertension, high stress levels, tinnitus, noise induced hearing loss, sleep disturbances, and other harmful effects.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is noise?
2. What is noise pollution?
3. Discuss the health effects of noise pollution.

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UNIT 6 RADIATION AND HEALTH

CONTENTS

1.0 INTRODUCTION

Over the years, the impact of radiation on human health and the environment have been studied. Although it is still a growing field in environmental health, it's been discovered that certain types of radiation, most especially ionizing radiation can be harmful to human health if exposed to them. This unit will further discuss radiation forms, its potency and health effects.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the forms of radiation
- explain the health effects of ionizing radiation.

3.0 MAIN CONTENT

3.1 What is Radiation?

Radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium. This includes; electromagnetic radiation (such as radio waves, microwaves, visible light, x-rays, and gamma radiation), particle radiation (such as alpha radiation (α), beta radiation (β), and neutron radiation) and acoustic radiation (such as ultrasound, sound, and seismic waves). Radiation can be categorized into ionizing or non-ionizing radiation depending on the energy of the radiated particles.

Natural radiation comes from many sources including more than 60 naturally-occurring radioactive materials found in soil, water and air. Radon, a naturally-occurring gas, emanates from rock and soil and is the main source of natural radiation. Every day, people inhale and ingest radionuclides from air, food and water. Cosmic rays are also natural sources of radiation. Human exposure to radiation also comes from anthropogenic sources ranging from nuclear power generation to medical uses of radiation for diagnosis or treatment such as X-ray machines.

3.2 Ionizing Radiation

Radiation with sufficiently high energy can ionize atoms; that is to say it can knock electrons off atoms and create ions. Ionization occurs when an electron is stripped from an electron shell of the atom, which leaves the atom with a net positive charge. Ionizing radiation from a radioactive material or a nuclear process such as fission or fusion, involves particle radiation. Particle radiation is a subatomic particles accelerated to relativistic speeds by nuclear reactions. The main types of nuclear particles are alpha particles, beta particles, neutrons and protons. Much ionizing radiation originates from radioactive materials and space (cosmic rays), and as such is naturally present in the environment, since most rock and soil has small concentrations of radioactive materials. The radiation is invisible and not directly detectable by human senses; as a result, instruments such as Geiger counters are usually required to detect its presence.

Some forms of ionizing radiation include;

Ultraviolet radiation: Ultraviolet, of wavelengths from 10 nm to 125 nm, ionizes air molecules, causing it to be strongly absorbed by air and by ozone (O_3) in particular. Ionizing UV therefore does not penetrate Earth's atmosphere to a significant degree. Although present in space, this part of the UV spectrum is not of biological importance, because it does not reach living organisms on Earth.

X-ray: X-rays are electromagnetic waves with a wavelength less than about 10^{-9} m. When an X-ray photon collides with an atom, the atom may absorb the energy of the photon and boost an electron to a higher orbital level or if the photon is very energetic, it may knock an electron from the atom, causing the atom to ionize. Generally, larger atoms are more likely to absorb an X-ray photon since they have greater energy differences between orbital electrons. Soft tissue in the human body is composed of smaller atoms than the calcium atoms that make up bone, hence there is a contrast in the absorption of X-rays. X-ray machines are specifically designed to take advantage of the absorption difference between bone and soft tissue, allowing physicians to examine structure in the human body.

Gamma Radiation: Gamma (γ) radiation consists of photons with a wavelength less than $3x10^{-11}$ meters. Gamma radiation emission is a nuclear process that occurs to free an unstable nucleus of excess energy after most nuclear reactions. Both alpha and beta particles have an electric charge and mass, and thus are quite likely to interact with other atoms in their path. Gamma radiation, however, is composed of photons, which have neither mass nor electric charge and, as a result, penetrates much further through matter than either alpha or beta radiation. Gamma rays can be stopped by a sufficiently thick or dense layer of material.

Alpha radiation: Alpha particles interact with matter strongly due to their charges and combined mass and at their usual velocities only penetrate a few centimeters of air or a few millimeters of low density material. This means that alpha particles do not penetrate the outer layers of dead skin cells and cause no damage to the live tissues below. Alpha radiation is dangerous when alpha-emitting radioisotopes are ingested or inhaled. This brings the radioisotope close enough to sensitive live tissue for the alpha radiation to damage cells. Examples of highly poisonous alpha-emitters are all isotopes of radium, radon, and polonium, due to the amount of decay that occur in these short half-life materials.

Beta radiation: Beta (β^{-}) radiation consists of an energetic electron. It is more penetrating than alpha radiation, but less than gamma. Beta radiation from radioactive decay can be stopped with a few centimeters of plastic or a few millimeters of metal. It occurs when a neutron decays into a proton in a nucleus, releasing the beta particle and an antineutrino. It is sometimes used therapeutically in radiotherapy to treat superficial tumors.

3.3 Non-Ionization Radiation

The kinetic energy of particles of non-ionizing radiation is too small to produce charged ions when passing through matter. For non-ionizing electromagnetic radiation, the associated particles (photons) have only sufficient energy to change the rotational, vibrational or electronic valence configurations of molecules and atoms. The electromagnetic spectrum is the range of all possible electromagnetic radiation frequencies. The non-ionizing portion of electromagnetic radiation consists of electromagnetic waves that are not energetic enough to detach electrons from atoms or molecules and hence cause their ionization. These include radio waves, microwaves, infrared, and visible light.

Some forms of non-ionizing radiation include;

Ultraviolet light: The lower part of the spectrum of ultraviolet, called soft UV, from 3 eV to about 10 eV, is non-ionizing.

Visible light: Visible light is a very narrow range of electromagnetic radiation of a wavelength that is visible to the human eye (380–750 nm in wavelength) which equates to a frequency range of 790 to 400 THz respectively.

Infrared: Infrared (IR) light is electromagnetic radiation with a wavelength between 0.7 and 300 micrometers, which corresponds to a frequency range between 430 and 1 THz respectively. IR wavelengths are longer than that of visible light, but shorter than that of microwaves.

Microwave: Microwaves are electromagnetic waves with wavelengths ranging from as short as one millimeter to as long as one meter, which equates to a frequency range of 300 MHz to 300 GHz.

Radio waves: Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared light. Like all other electromagnetic waves, they travel at the speed of light. Naturally occurring radio waves are made by lightning, or by certain astronomical objects. Artificially generated radio waves are used for fixed and mobile radio communication, broadcasting, radar and other navigation systems, satellite communication, computer networks and innumerable other applications.

3.4 Health Effects of Ionizing Radiation

Ionizing radiation has many practical uses in medicine, research and construction, but presents a health hazard if used improperly. Radiation damage to tissue and/or organs depends on the dose of radiation received, or the absorbed dose which is expressed in a unit called the gray (Gy). The potential damage from an absorbed dose depends on the type of radiation and the sensitivity of different tissues and organs. Exposure to radiation causes damage to living tissue; high doses result in Acute radiation syndrome (ARS), with skin burns, hair loss, internal organ failure and death while any dose may result in an increased chance of cancer and genetic damage.

4.0 CONCLUSION

Radiation is in many forms and can come from natural and anthropogenic sources. The major classes of radiation are ionizing and non-ionizing radiation and the difference between them is the ability of ionizing radiation to strip atoms of electrons, thus energizing them. Ionizing radiation can have harmful effects on human health.

5.0 SUMMARY

In this unit we have learnt that:

- Radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium.
- Radiation can be categorized into ionizing or non-ionizing radiation depending on the energy of the radiated particles.
- Natural radiation comes from many sources including more than 60 naturally-occurring radioactive materials found in soil, water and air.
- Human exposure to radiation also comes from anthropogenic sources ranging from nuclear power generation to medical uses of radiation for diagnosis or treatment such as X-ray machines.
- Ionization occurs when an electron is stripped from an electron shell of the atom, which leaves the atom with a net positive charge.
- The main types of nuclear particles are alpha particles, beta particles, neutrons and protons.
- The kinetic energy of particles of non-ionizing radiation is too small to produce charged ions when passing through matter.
- Ionizing radiation has many practical uses in medicine, research and construction, but presents a health hazard if used improperly.
- Exposure to radiation causes damage to living tissue; high doses result in Acute radiation syndrome (ARS), with skin burns, hair loss, internal organ failure and death while any dose may result in an increased chance of cancer and genetic damage.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain radiation.
2. Discuss ionizing radiation.
3. Discuss non-ionizing radiation.

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MODULE 3 SANITATION AND WASTE MANAGEMENT

UNIT 1 SANITATION AND EXCRETA DISPOSAL

CONTENTS

1.0 INTRODUCTION

Proper sanitation and excreta disposal is important to the health of populations and is an important component of public health. Epidemics have occurred due to poor sanitation and excreta disposal. Pathogens and their vectors thrive in unsanitary conditions and these can contaminate food and water that is consumed. In this unit, we will consider what proper sanitation and excreta disposal entails and also look at various types and methods of sanitation systems and excreta disposal.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the different types of sanitation systems
- describe some common excreta disposal methods
- explain health conditions associated with poor sanitation.

3.0 MAIN CONTENT

3.1 Concept of Sanitation and Excreta Disposal

Sanitation refers to public health conditions related to clean environment, potable drinking water and adequate treatment and disposal of sewage. Preventing human contact with faeces, for example, is part of sanitation, as is hand washing with soap. Sanitation systems aim to protect human health by providing a clean environment that will stop the transmission of disease, especially through the fecal-oral route. For example, diarrhoea, a main cause of malnutrition and stunted growth in children can be reduced through sanitation.

A sanitation system includes the capture, storage, transport, treatment and disposal or reuse of human waste. There are many different sanitation technologies, processes and approaches. Some examples are container-based sanitation, community-led total sanitation, ecological sanitation, emergency sanitation, environmental sanitation, onsite sanitation and sustainable sanitation.

The overall purposes of sanitation are to provide a healthy living environment for everyone, to protect the natural resources (such as surface water, groundwater, soil), and to provide safety, security and dignity for people when they defecate or urinate. Sanitation technologies may involve building structures like sewer systems, sewage treatment, surface runoff treatment and solid waste landfills. These structures are designed to treat wastewater and municipal solid waste. Sanitation technologies may also take the form of relatively simple onsite sanitation systems such as a simple pit latrine or other type of non-flush toilet for the excreta management part.

3.2 Types of Sanitation Systems

Basic sanitation: This is defined as the use of improved sanitation facilities that are not shared with other households.

Container-based sanitation: Container-based sanitation (CBS) refers to a sanitation system where human excreta is collected in sealable, removable containers that are transported to treatment facilities e.g. portable toilets.

Ecological sanitation (ECOSAN): Ecological sanitation systems safely recycle excreta resources to crop production in such a way that the use of non-renewable resources is minimized. When properly designed and operated, ECOSAN systems provide a hygienically safe, economical, and closed-loop system to convert human excreta into nutrients to be returned to the soil and water to be returned to the land.

Emergency sanitation: Emergency sanitation is required in situations including natural disasters and relief for refugees and Internally Displaced Persons (IDPs). There are three phases; immediate, short term and long term. In the immediate phase, the focus is on managing open defecation, and toilet technologies might include pit latrines and container-based toilets. Providing handwashing facilities and management of fecal sludge are also part of emergency sanitation.

Environmental sanitation: Environmental sanitation encompasses the control of environmental factors that are connected to disease transmission. This includes, solid waste management, water and wastewater treatment, industrial waste treatment and noise and pollution control.

3.3 Common Excreta Disposal Methods

Pit latrines: A pit latrine or pit toilet is a type of toilet that collects human faeces in a hole in the ground. When properly built and maintained they can decrease the spread of disease by reducing the amount of human faeces in the environment from open defecation. This decreases the transfer of pathogens between feces and food by flies. A pit latrine generally consists of three major parts: a hole in the ground, a slab or floor with a small hole, and a shelter. The shelter is often known as an outhouse. The pit is typically at least 3 meters (10 feet) deep and 1 m (3.2 feet) across.

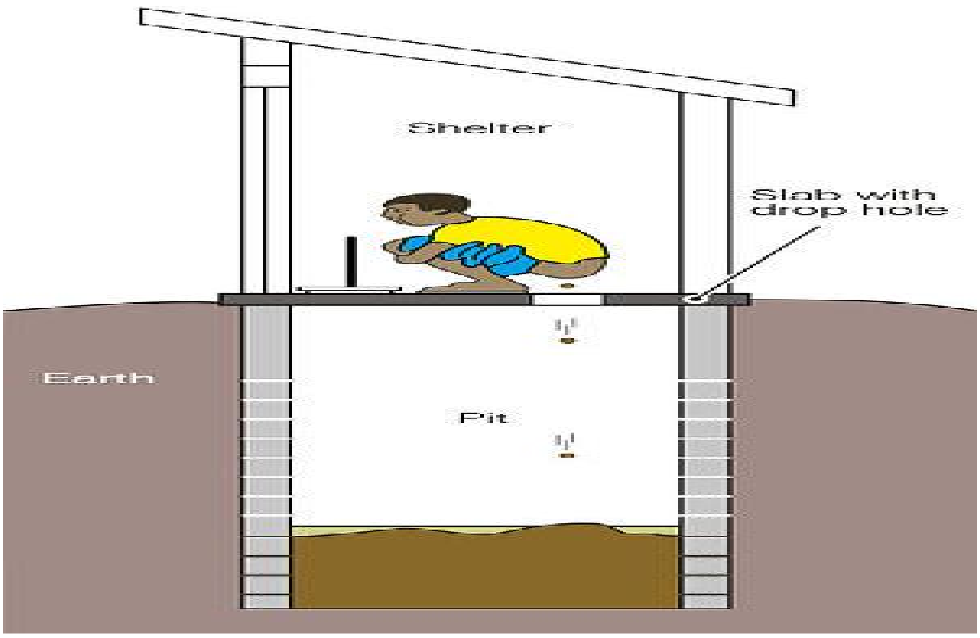

Fig 3: A pit latrine

Pour-Flush: In a pour-flush pit latrine, a squatting toilet with a water seal (U-trap or siphon) is used over one or two offset pits instead of a plain hole or seat. Therefore, these types of toilets do require water for flushing but otherwise have many of the same characteristics as simple pit latrines. An alternative to U-trap or siphon designs is to incorporate a counter-weighted trap door mechanism that provides an air-tight water seal in the closed position.

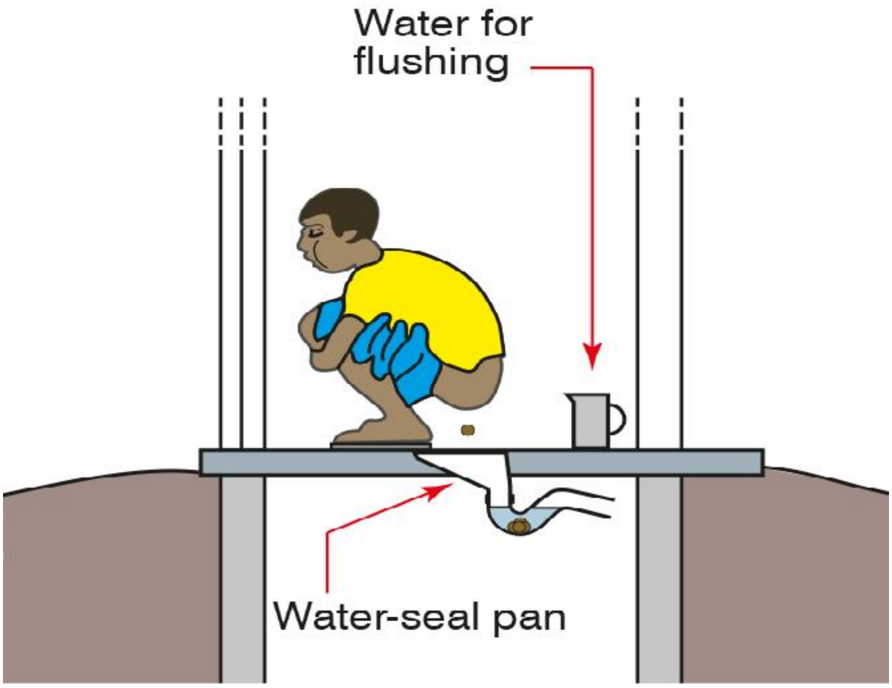

Fig. 4: A Pour-Flush Pit Latrine

Ventilated Improved Pit Latrines: The ventilated improved pit latrine (VIP) is a pit latrine with a black pipe (vent pipe) fitted to the pit and a screen (flyscreen) at the top outlet of the pipe. VIP latrines are an improvement to overcome the disadvantages of simple pit latrines, e.g. fly and mosquito nuisance and unpleasant odors. The smell is carried upwards by the chimney effect and flies are prevented from leaving the pit and spreading disease. The principal mechanism of ventilation in VIP latrines is the action of wind blowing across the top of the vent pipe. The wind creates a strong circulation of air through the superstructure, down through the squat hole, across the pit and up and out of the vent pipe. Unpleasant fecal odors from the pit contents are thus sucked up and exhausted out of vent pipe, leaving the superstructure odor-free.

Water closet systems: A water closet (WC) is a toilet that disposes of human excreta by using water to flush it through a drainpipe to another location for disposal, thus maintaining a separation between humans and their excreta. Water closets usually incorporate an "S", "U", "J", or "P" shaped bend that causes the water in the toilet bowl to collect and act as a seal against sewer gases (trapping the gases). Since flush toilets are typically not designed to handle waste on site, their drain pipes must be connected to waste conveyance and waste treatment systems. When a toilet is flushed, the wastewater flows into a septic tank or sewage system and from there to a sewage treatment plant.

Aqua Privy: The aqua privy is essentially a small septic tank located directly below a squatting plate which has a drop pipe extending below the liquid level in the tank to form a simple water seal. To prevent odor, fly and mosquito nuisance in the toilet, the water seal has to be maintained by adding sufficient water per toilet visit to the tank via the drop-pipe to replace any losses. The excreta are deposited directly into the tank where they are decomposed anaerobically similar to a septic tank. A housing or shed is built over the tank. A vent pipe with a fly screen at the top end is attached to the housing. A water-tight tank is desirable to minimize losses. An effluent (overflow) pipe is installed above the level of the drop-pipe.

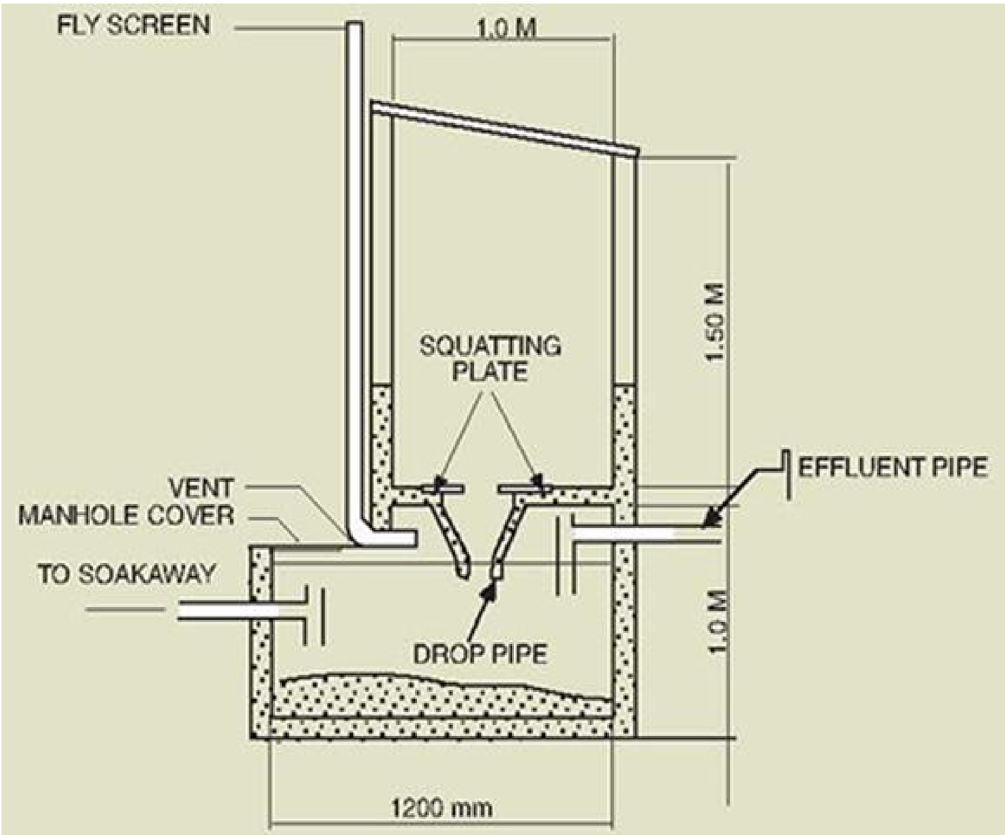

Fig. 5: An Aqua Privy system

3.4 Health Problems of Poor Sanitation and Excreta Disposal

Adequate sanitation in conjunction with good hygiene and safe water are essential to good health. Lack of proper sanitation causes diseases. The lack of clean water and poor sanitation causes many diseases and the spread of diseases. It is estimated that inadequate sanitation is responsible for 4% of deaths and 5.7% of disease burden worldwide. Some common diseases attributable to poor sanitation are;

Diarrhoea: Lack of sanitation especially open defecation is a major risk factor for diarrhoea. Diarrhoea is primarily transmitted through faecal-oral routes**.** Deaths resulting from diarrhoea are estimated to be between 1.6 and 2.5 million deaths every year. Most of the affected are young children below the ages of five. Children suffering from diarrhea are more vulnerable to become underweight which makes them more vulnerable to other diseases such as acute respiratory infections and malaria.

Infections with intestinal helminths (worms): approximately two billion people are infected with soil-transmitted helminths worldwide. They are transmitted by eggs present in human faeces which in turn contaminate soil in areas where sanitation is poor.
Other disease conditions that can be associated with poor sanitation include; malaria, malnutrition, cholera, ringworm, schistosomiasis, typhoid fever and poliomyelitis.

4.0 CONCLUSION

In this unit, we have looked at sanitation as an important aspect of public health involved in providing clean environment, potable water and adequate treatment of sewage. We also look into different sanitation systems and excreta disposal methods such as pit latrines, Ventilated Improved Pit Latrines etc. Furthermore, we also discussed health conditions associated with poor sanitation and excreta disposal.

5.0 SUMMARY

In this unit we have learnt that:

- Sanitation refers to public health conditions related to clean environment, potable drinking water and adequate treatment and disposal of sewage.
- A sanitation system includes the capture, storage, transport, treatment and disposal or reuse of human waste.
- There are many different sanitation technologies, processes and approaches. Some examples are container-based

sanitation, community-led total sanitation, ecological sanitation, emergency sanitation, environmental sanitation, onsite sanitation and sustainable sanitation.

- The overall purposes of sanitation are to provide a healthy living environment for everyone, to protect the natural resources (such as surface water, groundwater, soil), and to provide safety, security and dignity for people when they defecate or urinate.
- Lack of proper sanitation causes diseases

6.0 TUTOR-MARKED ASSIGNMENT

1. What is sanitation?
2. Explain three types of sanitation systems.
3. Describe two excreta disposal methods.
4. List five health problems associated with poor sanitation.

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UNIT 2 WASTE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Many of our activities as humans either domestic or commercial, generate waste. Some of which can be harmful to us as humans, to animals and the environment at large. This has led to strategies and technologies being developed in order to mitigate this problem as waste management is closely associated with sanitation and as such is very important to human health and also environmental conservation. In this unit, we will look at waste management strategies and technologies as well as its benefits.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss and define waste management
- explain the different solid waste disposal methods and liquid waste management
- discuss waste hierarchy
- discuss the benefits of waste management.

3.0 MAIN CONTENT

3.1 What is waste management?

Waste management are all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things collection, transport, treatment and disposal of waste together with monitoring and regulation. Waste can take any form that is either solid, liquid, or gas and each have different methods of disposal and management. Waste management normally deals with all types of waste whether it was created in forms that are industrial, biological, household and special cases where it may pose a threat to human health. Waste management is aimed at reducing adverse effects of waste on health, the environment or aesthetics.

3.2 Solid Waste Management

Solid Waste Management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economics, aesthetic, engineering and other environmental considerations. As a result of human activities, solid waste is often generated and disposed off. This waste comes from homes, offices, industries and various other agricultural related activities. These solid wastes, if not properly managed can seriously affect the health of humans, wildlife and our environment. The following are major sources of solid waste;

Residential: Residences and homes where people live are some of the major sources of solid waste. Garbage from these places include food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes and special wastes like bulky household items like electronics, tires, batteries, old mattresses and used oil. Most homes have garbage bins where they can throw away their solid wastes in and later the bin is emptied by a garbage collecting firm or person for treatment.

Industrial: Industries are known to be one of the biggest contributors of solid waste. They include light and heavy manufacturing industries, construction sites, fabrication plants, canning plants, power and chemical plants. These industries produce solid waste in form of housekeeping wastes, food wastes, packaging wastes, ashes, construction and demolition materials, special wastes, medical wastes as well as other hazardous wastes.

Commercial: Commercial facilities and buildings are yet another source of solid waste today. Commercial buildings and facilities in this case refer to hotels, markets, restaurants, go downs, stores and office buildings. Some of the solid wastes generated from these places include plastics, food wastes, metals, paper, glass, wood, cardboard materials, special wastes and other hazardous wastes.

Institutional: The institutional centers like schools, colleges, prisons, military barracks and other government centers also produce solid waste. Some of the common solid wastes obtained from these places include glass, rubber waste, plastics, food wastes, wood, paper, metals, cardboard materials, electronics as well as various hazardous wastes.

Construction and Demolition Areas: Construction sites and demolition sites also contribute to the solid waste problem. Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and building demolition sites. Some of the solid wastes produced in these places include steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.

Municipal services: The urban centers also contribute immensely to the solid waste crisis in most countries today. Some of the solid waste brought about by the municipal services include, street cleaning, wastes from parks and beaches, wastewater treatment plants, landscaping wastes and wastes from recreational areas including sludge.

Treatment Plants and Sites: Heavy and light manufacturing plants also produce solid waste. They include refineries, power plants, processing plants, mineral extraction plants and chemicals plants. Among the wastes produced by these plants include, industrial process wastes, unwanted specification products, plastics, metal parts just to mention but a few.

Agriculture: Crop farms, orchards, dairies, vineyards and feedlots are also sources of solid wastes. Among the wastes they produce include agricultural wastes, spoiled food, pesticide containers and other hazardous materials.

Biomedical: This refers to hospitals and biomedical equipment and chemical manufacturing firms. In hospitals there are different types of solid wastes produced. Some of these solid wastes include syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals. All these require proper disposal or else they will cause a huge problem to the environment and the people in these facilities.

3.3 Solid Waste Disposal Methods

3.3.1 Sanitary Landfills

A landfill site (dumpsite) is a site for the disposal of waste materials by burial and the oldest form of waste treatment. Some landfills are also used for the temporary storage, consolidation and transfer, or processing of waste material (sorting, treatment, or recycling).

During landfill operations, waste collection vehicles use the existing road network on their way to the tipping face or working front, where they unload their contents. After loads are deposited, compactors or bulldozers can spread and compact the waste on the working face. Typically, in the working face, the compacted waste is covered with soil or alternative materials daily. Alternative waste-cover materials include chipped wood or sawdust. The space that is occupied daily by the compacted waste and the cover material is called a daily cell. Waste compaction is critical to extending the life of the landfill. Factors such as waste compressibility, waste-layer thickness and the number of passes of the compactor over the waste affect the waste densities.

Case 3-1: Solid Waste Generation and Disposal Across Nigeria

Nnaji (2015) reported a solid waste generation rate of 0.13 kg/capita/day in Ogbomosho and about 0.71 kg/capita/day in Ado-Ekiti. Food waste was reportedly the major constituent (50%) of general municipal solid waste in Nigerian cities. In his study, there was a continuous increase in generation of plastics, water proof materials and diapers. Furthermore, open dumps were observed to be the main form of waste disposal within the cities which can be attributed to the dysfunctional state of government-run waste management authorities. This was evidenced by data reporting that more than 50% of residents of Maiduguri, Borno State in northern Nigeria and Ughelli, Delta State in southern Nigeria dispose of their waste in open dumps. Indiscriminate and inappropriate waste disposal can be associated with the prevalence of toxic heavy metals in

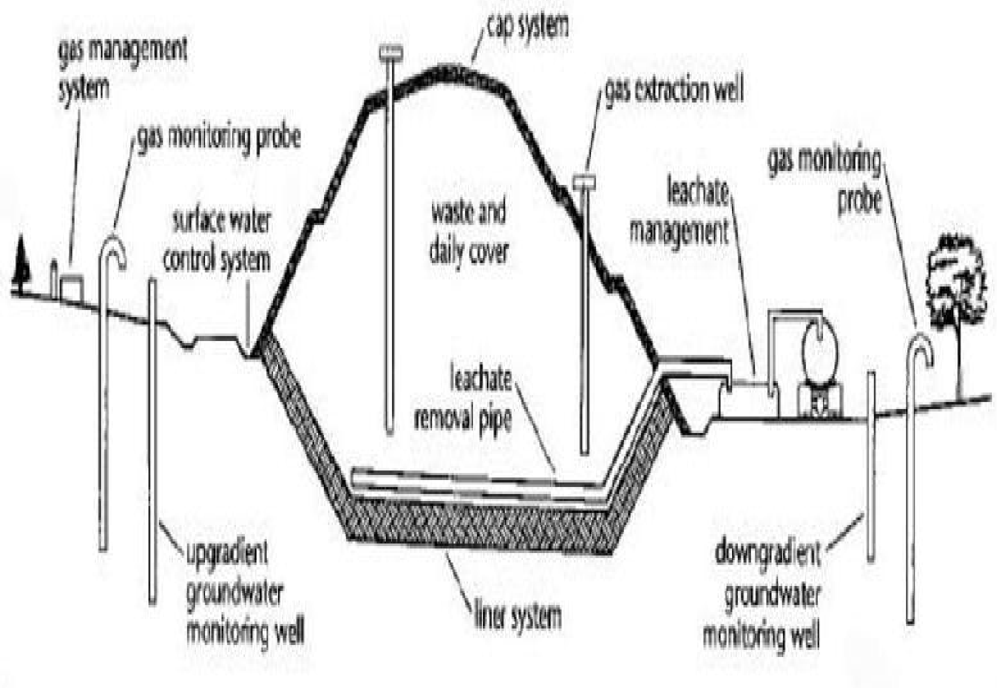

Fig. 6: A sanitary landfill design

3.3.2 Incineration

Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration of waste materials converts the waste into ash, flue gas and heat. The ash is mostly formed by the inorganic constituents of the waste, and may take the form of solid lumps or particulates carried by the flue gas. The flue gases must be cleaned of gaseous and particulate pollutants before they are dispersed into the atmosphere. In some cases, the heat generated by incineration can be used to generate electric power.

Incinerators reduce the solid mass of the original waste by 80–85% and the volume, depending on composition and degree of recovery of materials such as metals from the ash for recycling. Incineration has particularly strong benefits for the treatment of certain waste types such as clinical wastes, e.g. syringes and certain hazardous wastes where pathogens and toxins can be destroyed by high temperatures. Examples include chemical multi-product plants with diverse toxic or very toxic wastewater streams, which cannot be routed to a conventional wastewater treatment plant.

3.3.3 Composting

Composting of waste is an aerobic method of decomposing solid wastes. The process involves decomposition of organic waste into humus known as compost which is a good fertilizer for plants. At the simplest level, the process of composting requires making a heap of wet organic matter known as green waste (leaves, food waste) and waiting for the materials to break down into humus after a period of weeks or months. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. Worms and fungi further break up the material. Bacteria requiring oxygen to function (aerobic bacteria) and fungi manage the chemical process by converting the inputs into heat, carbon dioxide and ammonium.

Compost is rich in nutrients. It is used in gardens, landscaping, horticulture, and agriculture. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover. The composting process involves three major phases:

- An initial, mesophilic phase, in which the decomposition is carried out under moderate temperatures by mesophilic microorganisms.
- As the temperature rises, a second, thermophilic phase starts, in which the decomposition is carried out by various thermophilic bacteria under high temperatures.
- As the supply of high-energy compounds dwindles, the temperature starts to decrease, and the mesophiles once again predominate in the maturation phase.

3.4 Solid Waste Management hierarchy

The waste management hierarchy refers to the terms “reduce, reuse and recycle” which classify waste management strategies according to their desirability in terms of waste minimization. The waste hierarchy remains the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract maximum benefits from products and to generate the minimum amount of waste.

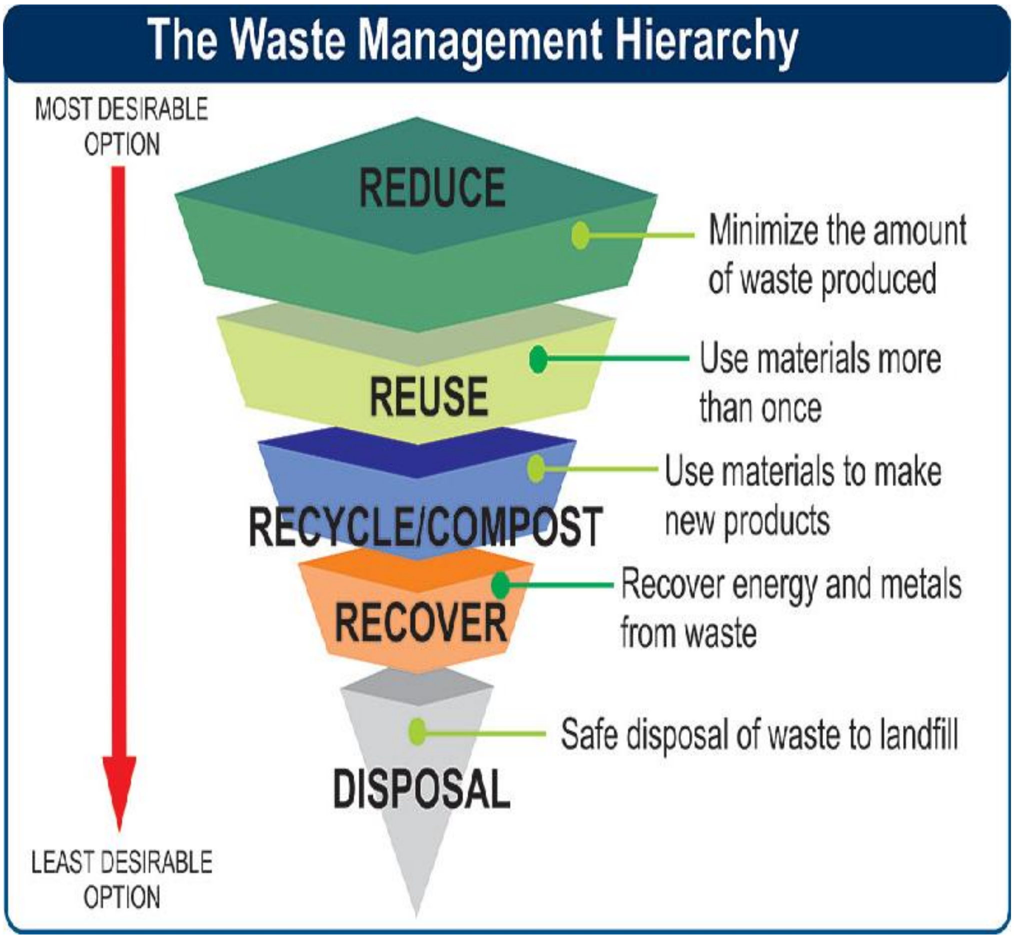

Fig. 7: Waste Management Hierarchy

The waste hierarchy is represented as a pyramid because the basic premise is for policy to take action first and prevent the generation of waste. The next step or preferred action is to reduce the generation of waste i.e. by re-use. The next is recycling which would include composting. Following this step is material recovery and waste-to-energy. Energy can be recovered from processes i.e. landfill and combustion, at this level of the hierarchy. The final action is disposal, in landfills or through incineration without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered. The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management.

Recycling: Recycling is a resource recovery practice that refers to the collection and reuse of waste materials. The materials from which the items are made can be reprocessed into new products. Material for recycling may be collected separately from general waste using dedicated bins and collection vehicles. The most common consumer products recycled include aluminum such as beverages cans, copper such as wire, steel from food and aerosol cans, old steel furnishings or equipment, rubber tires, polyethylene

(PET) bottles, glass bottles and jars, paperboard cartons, newspapers, magazines and light paper.

Re-use: Recoverable materials that are organic in nature, such as plant material, food scraps, and paper products can be recovered through composting and digestion processes to decompose organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. In addition, waste gas from the digestion process (such as methane) can be captured and used for generating electricity and heat. The intention of biological processing in waste management is to control and accelerate the natural process of decomposition of organic matter.

Energy recovery: Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolyzation, anaerobic digestion, and landfill gas recovery. This process is often called waste-to-energy. Energy recovery from waste is part of the non-hazardous waste management hierarchy. Using energy recovery to convert non-recyclable waste materials into electricity and heat, generates a renewable energy source and can reduce carbon emissions by offsetting the need for energy from fossil sources as well as reduce methane generation from landfills.

Resource recovery: Resource recovery is the systematic diversion of waste, which was intended for disposal, for a specific next use. It is the processing of recyclables to extract or recover materials and resources or convert to energy. These activities are performed at a resource recovery facility. Resource recovery is not only environmentally important, but it is also cost-effective. It decreases the amount of waste for disposal, saves space in landfills, and conserves natural resources.

3.5 Liquid Waste Management (Sewage or Wastewater treatment)

Wastewater is used water from any combination of domestic, industrial, commercial or agricultural activities. The characteristics of wastewater vary depending on the source. Types of wastewater include: domestic wastewater from households, municipal wastewater from communities (also called sewage) or industrial wastewater from industrial activities. Wastewater can contain the following classes of pollutants.
Physical: solid waste, rubbles, silt, etc.
Chemical: heavy metals, gases, organic materials, toxins, pharmaceutical etc.
Biological: bacteria, virus, protozoa and parasites.

3.5.1 Sewage/Wastewater Treatment Methods

Sewage or Wastewater treatment is the process of removing contaminants from wastewater and household sewage. Physical, chemical, and biological processes are used to remove contaminants and produce treated wastewater (or treated effluent) that is safer for the environment. A by-product of sewage treatment is usually a semi-solid waste or slurry, called sewage sludge. The sludge has to undergo further treatment before being suitable for disposal or application to land.

Treating wastewater has the aim to produce an effluent that will do as little harm as possible when discharged to the surrounding environment, thereby preventing pollution compared to releasing untreated wastewater into the environment. Sewage or Wastewater treatment generally involves the following stages;

Case 3-2: Domestic Wastewater Management in Minna

In 2013, Idris-Nda et al., conducted a study on domestic wastewater management in Minna. The daily amount of wastewater generated is 36,493,920 litres (36,494m^3). The physico-chemical composition of the domestic wastewater shows that pH was within the range of 7.5 - 8.7, temperature 29^oC - 30.1^oC, salinity 1051mg/l - 1329mg/l, chloride 240mg/l - 280mg/l, sodium 152mg/l - 178.7mg/l, potassium 84.35mg/l - 99.34mg/l, calcium 24.01mg/l - 48.1mg/l, magnesium 24.4mg/l - 39.04mg/l, sulphate 10mg/l - 19mg/l, carbonate 370.5mg/l - 525mg/l and bicarbonate 945.75mg/l - 1462.5mg/l. (Idris-Nda *et al.*, 2013).

Domestic wastewater, if not treated or disposed off appropriately can become a medium for pathogen growth. Community residents are exposed to these pathogens through contaminated drinking water, water bodies or eating contaminated food. Common ailments that afflict the inhabitants include malaria, typhoid and cholera.

3.5.1.1Pre-treatment

Pre-treatment removes all materials that can be easily collected from the raw sewage before they damage or clog the pumps and sewage lines of primary sedimentation tanks. Objects commonly removed during pretreatment include trash, tree limbs, leaves, branches, and other large objects. The solids are collected and later disposed in a landfill, or incinerated. Bar screens or mesh screens of varying sizes may be used to optimize solids removal. Pretreatment may include a sand or grit channel or chamber, where the velocity of the incoming sewage is adjusted to allow the settlement of sand, grit, stones, and broken glass.

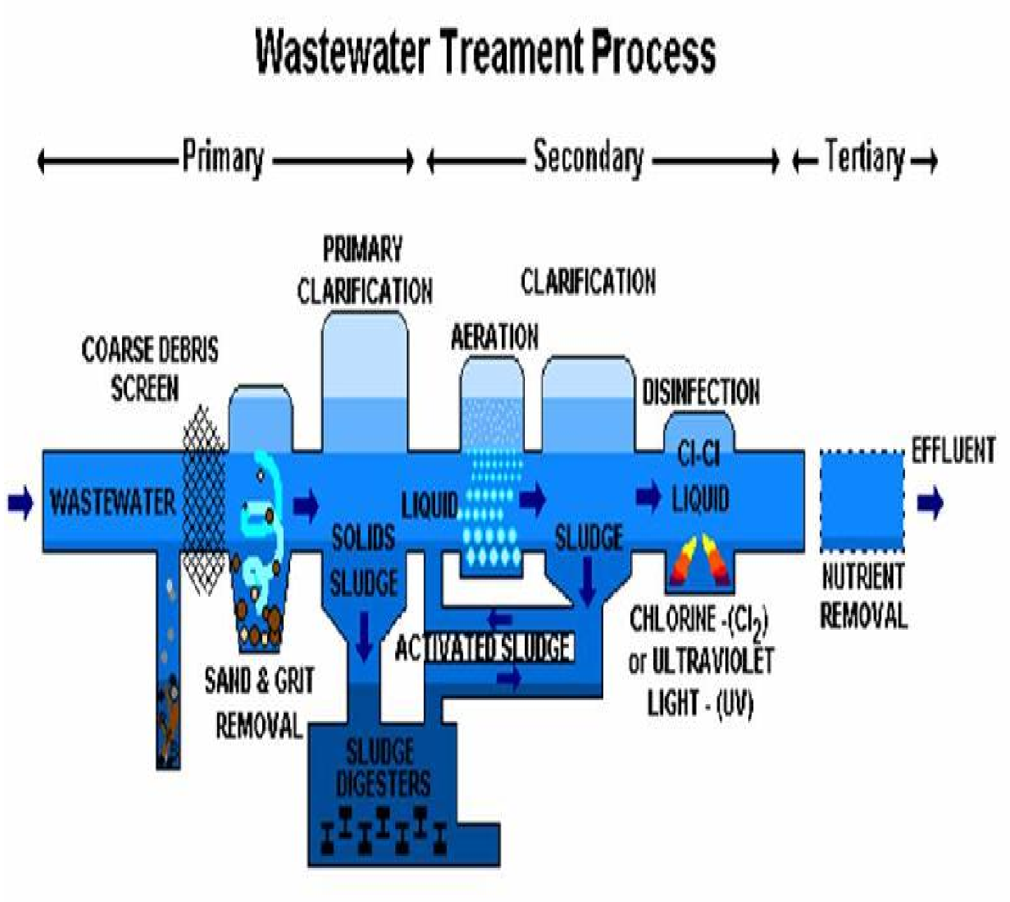

Fig. 8: Sewage and Wastewater treatment

3.5.1.2Primary treatment

Primary treatment consists of temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to secondary treatment. In this phase, sewage flows through large tanks, commonly called primary sedimentation tanks. The tanks are used to settle sludge while grease and oils rise to the surface and are skimmed off. Grease and oil from the floating material can sometimes be recovered for saponification (soap making).

3.5.1.3 Secondary treatment

Secondary treatment removes dissolved and suspended biological matter. Secondary treatment is typically performed by indigenous, water-borne micro-organisms in a managed habitat. Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment. Secondary treatment systems are classified as fixed-film or suspended-growth systems. Fixed-film or attached growth systems include trickling filters, constructed wetlands, bio-towers, and rotating biological contactors, where the biomass grows on media and the sewage passes over its surface while suspended-growth systems include activated sludge, where the biomass is mixed with the sewage and can be operated in a smaller space than trickling filters that treat the same amount of water. Some secondary treatment methods include a secondary clarifier to settle out and separate biological floc or filter material grown in the secondary treatment bioreactor.

Activated Sludge: The activated sludge process is a type of secondary wastewater treatment process for treating sewage or industrial wastewaters using aeration and a biological floc composed of bacteria and protozoa. The general arrangement of an activated sludge process includes; aeration tank where air (or oxygen) is injected in the mixed liquid, settling tank to allow the biological flocs (sludge) to settle, thus separating the biological sludge from the clear treated water. The raw wastewater is channeled into an aeration tank where microorganisms breaks down the organic components of the wastewater. It then flows into a settling tank or clarifier where the sludge settles and is re-applied into the raw wastewater. The treated effluent is then channeled into the environment.

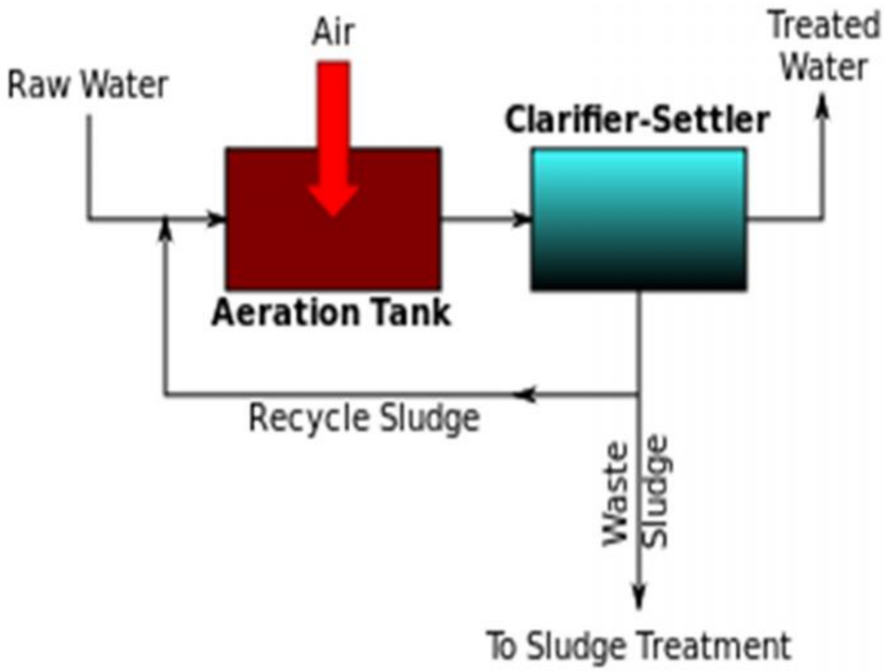

Fig. 9: Activated sludge process

Trickling Filter: A trickling filter consists of a fixed bed of rocks, gravel or plastic media over which sewage or other wastewater flows downward and causes a layer of microbial slime (biofilm) to grow, covering the bed of media. Aerobic conditions are maintained by splashing, diffusion, and either by forced-air flowing through the bed or natural convection of air if the filter medium is porous. Sewage flow enters at a high level and flows through the primary settlement tank. The supernatant from the tank flows into a dosing device, often a tipping bucket which delivers flow to the arms of the filter. The flush of water flows through the arms and exits through a series of holes pointing at an angle downwards. This propels the arms around distributing the liquid evenly over the surface of the filter media. The removal of pollutants from the waste water stream involves both absorption and adsorption of organic compounds and some inorganic species such as nitrite and nitrate ions by the layer of microbial biofilm.

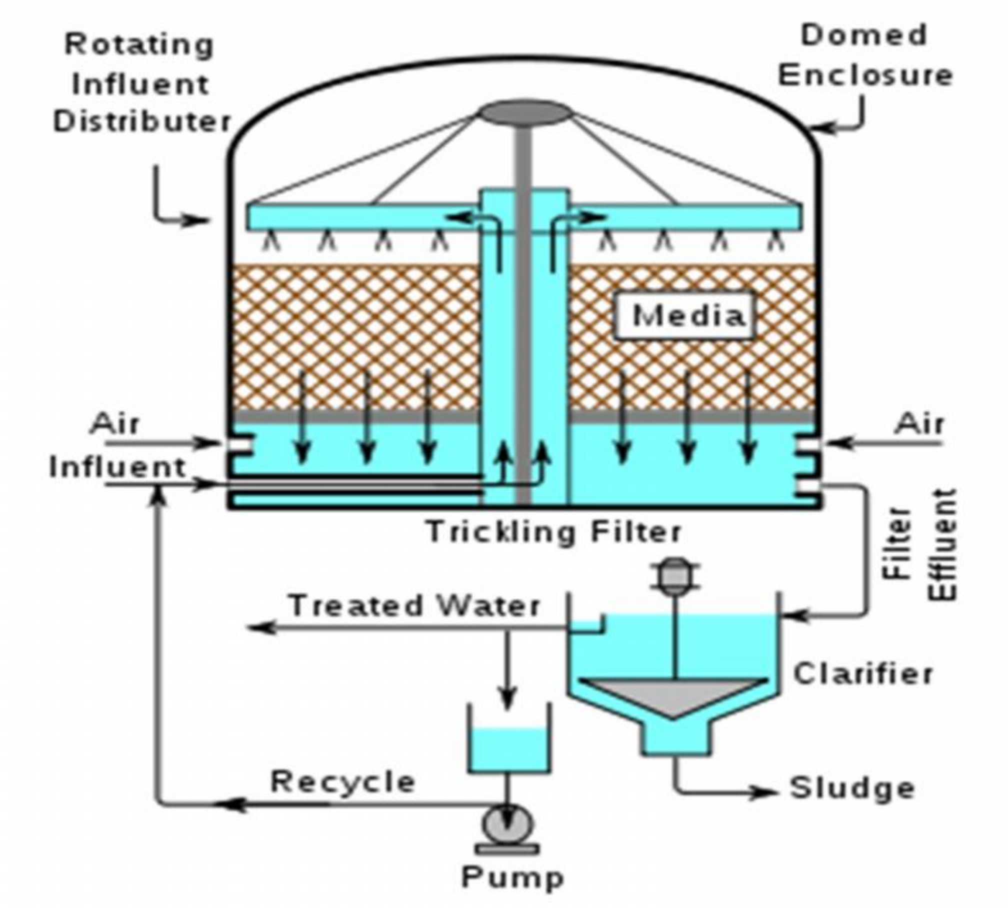

Fig. 10: A trickling filter system

3.5.1.4 Tertiary treatment

The purpose of tertiary treatment is to provide a final treatment stage to further improve the effluent quality before it is discharged to the receiving environment (sea, river, lake, wet lands, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. Sand filtration removes much of the residual suspended matter. Filtration over activated carbon removes residual toxins. Lagoons or ponds provide settlement and further biological improvement through storage in large man-made ponds or lagoons.

3.6 Hazardous and Hospital Waste Management

Hazardous waste is waste that has potential threats to public health or the environment. Hospital wastes are also classified as hazardous wastes because of the dangers they pose to human health and safety. Hazardous wastes are materials that are known to exhibit one or more of the following hazardous traits; ignitability, reactivity, corrosivity and toxicity. Hazardous wastes may be found in different physical states such as gaseous, liquids, or solids. A hazardous waste is a special type of waste because it cannot be disposed of by common means like other domestic products. Some types of wastes that may be hazardous are;

- Medical waste
- Construction debris
- Asbestos
- Mining waste
- Agricultural waste
- Radioactive waste
- Sewage sludge.

Medical Waste: Medical waste includes items that are generated from health care treatment or research facilities (human and non-human) and that have come in contact with body fluids (for example, blood) or other material that may contain infectious or disease-causing agents, for example:

- Soiled or blood-soaked bandages
- Culture dishes and other associated glassware
- Gloves, gowns, scalpels, and other items used during surgery
- Needles used to give injections or draw blood
- Body fluids and tissues.

Construction Debris: Unless a construction material is regulated separately (as asbestos is, for example) the construction debris waste stream consists of material generated from the construction and demolition of buildings and other facilities. Typically, this rubble is disposed of in landfills specifically for construction debris or in municipal solid waste landfills.

Asbestos: In developed countries such as the United States, asbestos is designated a special waste, with its own rules and regulations. This class of fibrous minerals has, in the past, been used extensively in consumer products such as car brake linings and construction materials. Most uses of asbestos have been banned in the United States because of its demonstrated capacity to cause disease in workers and other people who have frequent contact with the minerals. To prevent the airborne release of asbestos fibers, federal regulations provide detailed guidance on the removal, packaging, and disposal of asbestos-containing material.

Mining Waste: The extraction of metals, coal and oil from the earth’s crust generates huge quantities of waste materials. The volume of wastes from mining operations exceeds the volume of wastes from all other categories combined. The disposal of leftover rubble and liquid material is regulated by solid waste laws and regulations and also by water pollution controls and land-use or land-reuse laws and regulations.

Agricultural Waste: In technologically advanced countries, the production of food has become highly industrialized. This has resulted in an increased concentration of animals and thus increased localized production of wastes.

3.6.1 Hazardous and Hospital Waste Disposal Methods

Hazardous and hospital waste can be treated by chemical, thermal, biological, and physical methods.

Chemical methods: this includes ion exchange, precipitation, oxidation and reduction as well as neutralization.

Thermal methods: includes high-temperature incineration, which not only can detoxify certain organic wastes but also can destroy them. Special types of thermal equipment are used for burning waste in either solid, liquid, or sludge form. These include the fluidized-bed incinerator, multiple-hearth furnace, rotary kiln, and liquid-injection incinerator.

Biological methods: which includes treatment of certain organic wastes, such as those from the petroleum industry. One method used to treat hazardous waste biologically is called land farming. In this technique the waste is carefully mixed with surface soil on a suitable tract of land. Microbes that can metabolize the waste may be added, along with nutrients. In some cases a genetically engineered species of bacteria is used. Food or forage crops are not grown on the same site. Microbes can also be used for stabilizing hazardous wastes on previously contaminated sites; in that case the process is called bioremediation.

Physical methods: includes concentration, solidification and reduction of the volume of the waste. Physical processes include evaporation, sedimentation, flotation, and filtration.

3.7 Benefits of Waste Management

Waste is a valuable resource if addressed correctly, through policy and practice. With rational and consistent waste management practices there is an opportunity to reap a range of benefits. Those benefits include:
Economic: Improving economic efficiency through the means of resource use, treatment and disposal and creating markets for recycles can lead to efficient practices in the production and consumption of products and materials resulting in valuable materials being recovered for reuse and the potential for new jobs and new business opportunities.
Social: By reducing adverse impacts on health by proper waste management practices, the resulting consequences are more appealing settlements. Better social advantages can lead to new sources of

employment and potentially lifting communities out of poverty especially in some of the developing poorer countries and cities.

Environmental: Reducing or eliminating adverse impacts on the environment through reducing, reusing and recycling, and minimizing resource extraction can provide improved air and water quality and help in the reduction of greenhouse gas emissions.

Inter-generational Equity: Following effective waste management practices can provide subsequent generations a more robust economy, a fairer and more inclusive society and a cleaner environment.

4.0 CONCLUSION

In this Unit, we have considered what waste management entails, solid waste disposal methods such as landfills, incineration and composting as well as liquid waste management which can be classified into pretreatment, primary, secondary and tertiary treatment. Waste management strategies can also be prioritized through a hierarchical system and it has tremendous benefits.

5.0 SUMMARY

In this unit we have learnt that:

- Waste management are all the activities and actions required to manage waste from its inception to its final disposal.
- Waste can take any form that is either solid, liquid, or gas and each have different methods of disposal and management.
- A landfill site (dumpsite) is a site for the disposal of waste materials by burial and the oldest form of waste treatment.
- Incineration is a waste treatment process that involves the combustion of organic substances contained in solid waste materials.
- Composting of waste is an aerobic method of decomposing solid wastes. The process involves decomposition of organic waste into humus known as compost which is a good fertilizer for plants.
- Sewage or Wastewater is the process of removing contaminants from wastewater and household sewage.
- The waste management hierarchy refers to the terms “reduce, reuse and recycle” which classify waste management strategies according to their desirability in terms of waste minimization.
- Hazardous waste is waste that has potential threats to public health or the environment.

- Hazardous and hospital waste can be treated by chemical, thermal, biological, and physical methods.
- Waste is a valuable resource if addressed correctly, through policy and practice. With rational and consistent waste management practices there is an opportunity to reap a range of benefits.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is waste management?
2. Explain one solid waste disposal method.
3. Describe the activated sludge and trickling filter systems.
4. Explain the benefits of waste management.

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MODULE 4 HOUSING, RECREATIONAL AND WORKPLACE HEALTH

UNIT 1 HOUSING AND HEALTH

CONTENTS

1.0 INTRODUCTION

Housing in the modern concept includes not only the physical structure providing shelter, but also the immediate surroundings and the related community services and facilities. There is considerable evidence that housing conditions do affect health status. This therefore makes housing an important factor for health and in this unit, we will consider housing standards in general, the situation in Nigeria and effects of poor housing.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the housing standards and indicators
- discuss Nigeria's housing efforts
- identify the health effects of poor housing.

3.0 MAIN CONTENT

3.1 Definition and Standards

Housing refers to houses or buildings collectively; accommodation of people; planning or provision of accommodation by an authority. Housing is an important determinant of health and substandard housing is a major public health issue. Housing standards depend on conventional factors such as per capita space and floor space and on social and economic characteristics such as; family income, family size and composition, standard of living, life style, stage in life cycle, education and cultural factors. Despite the cultural, climate and social diversities, housing standards vary from country to country, region to region, etc. but then minimum standards are still maintained by all country building regulations.

Typical housing standards is as follows:

Site: elevated, accessible, away from breeding places, away from nuisances, in pleasant surroundings, the soil should be dry for good foundation, subsoil water should be below 10 feet.

Set Back: this is an open space around the house. In rural area built up area should not exceed one-third of the total area and in the urban area it should not exceed two-thirds of the total area (for proper lighting and ventilation).

Floor: should be impermeable, smooth and free from cracks/crevices, damp-proof and height of the plinth about 2 to 3 feet.

Walls: should be reasonably strong, have low heat capacity, weather resistant unsuitable for harbourage of rat and vermin, not easily damaged, and smooth

Roof: the height of the roof should not be less than 10 feet in the absence of air-conditioning for comfort. It should have a low heat transmittance coefficient

Rooms: Number of living rooms should not be less than two. The no and area of rooms should be increased according to size of family not to compromise recommended floor space per person.

Floor Area: Floor area of a room should be at least 120sq ft for occupancy by more than one person and at least 100 sqft for occupancy by a single person. The floor area available in living rooms per person should not be less than 50 sqft; the optimum is 100sq ft.

Cubic space: The height of rooms should be such as to give an air space of at least 500c.ft per capita, preferably 1,000 c.ft.

Windows: Every living room should be provided with at least 2 windows. Windows should be placed at a height of not more than 3 ft above the ground in the living rooms, window area should be 1/5th of the floor area. Doors and windows combined should have 2/5th the floor area.

Lighting: The daylight factor should exceed 1 percent over half the floor area.

Kitchen: Every dwelling house must have a separate kitchen. It must be protected against dust and smoke, adequately lighted.

Privy: A sanitary privy is a must in every house, belonging exclusively to it and readily accessible.

Garbage and refuse: Should be removed from the dwelling at least daily and disposed of in a sanitary manner.

Water supply: The house should have safe and adequate water supply at all times.

3.2 Indicators of housing

Indicators are used for measuring quality of life
Physical: floor space, cubic space, room height, persons per room, rooms per dwelling, environmental quality (air, light, ventilation, water, noise, waste disposal etc.)

Economic: Cost of the building, rental levels, taxes, expenditure on housing, etc.

Social: this includes the following;

Indicators related to prevention of illness

- Frequency of illness due to inadequate waste collection and management
- Frequency of illness associated with contaminated water sources
- Frequency of insect borne diseases
- Frequency of illness due to accidents
- Frequency of zoonotic illnesses
- Access to medical facility

Indicators related to comfort and psychosocial wellbeing
Comfort related:

- Thermal comfort
- Acoustic comfort
- Visual comfort
- Spatial comfort

Psycho-social well-being:
- Frequency of suicides in the neighbourhood
- Neglected or abandoned youth in the neighbourhood
- Drug abuse (including alcohol) in the neighbourhood

3.3 Overcrowding

This refers to the situation in which more people are living within a single dwelling than there is space for, so that movement is restricted, privacy secluded, hygiene impossible, rest and sleep difficult. The degree of overcrowding can be expressed as the number of persons per room, i.e. number of persons in the household divided by the number of rooms in the dwelling.

Persons per room

1 room	2 persons
2 rooms	3 persons
3 rooms	5 persons
4 rooms	7 persons
5 or more	10 persons (plus 2 for each room)

It can also be expressed in terms of the floor space:

110 sqft or more	2 persons
90-100 sqft	1 ½ persons
70-90 sqft	1 person
50-70 sqft	½ person
Under 50 sqft	nil

(Note; A baby under 12 months is not counted; children between 1 to 10yrs counted as half a unit)

3.4 Housing in Nigeria

In 1972, the Nigerian government aimed to build 59,000 housing units, but by 1975 - 1980 (3rd Development Plan period), only 15% completed. By the Millennium Development Goals of 2007 report, housing had reached a crisis point with only 31.1% of the population had secured tenure. By the year 2000, Nigeria required 12 and 14 million dwelling units which will triple by 2020. Nigeria has witnessed a rapid rate of urbanization in the last two decades. It is estimated that over 40% of the Nigerian population now live in urban areas. The rapid rate of urbanization has brought with it some significant problems including a shortage of housing, overcrowding, traffic congestion, environmental degradation, inadequate infrastructure and services, etc. In recognition of these problems, the National Rolling Plans since 1990 have factored in National Housing Policy instruments for implementing the National Housing Programme. Furthermore, the National Housing Fund and an Infrastructural Development Fund have been put in place to facilitate the attainment of the goals of sustainable human settlement in the country.

The National Housing Policy was formulated and launched in 1991. The document outlines policies and strategies to provide decent housing for all by the year 2000 or in the shortest possible time. National Urban Development Policy was formulated in 1992 to provide guidelines for urban development and management. National Construction Policy was promulgated in 1994

3.5 Health Effects of Poor Housing

Common health conditions associated with poor housing conditions are:

- Respiratory infection: common cold, tuberculosis, influenza, diphtheria, bronchitis, measles, whooping cough etc.
- Skin infections: scabies, ringworm, impetigo, leprosy
- Rat infestation: plague
- Arthropods: Houseflies, mosquitoes, fleas and bugs
- Accidents
- Morbidity and mortality
- Psychosocial effects.

4.0 CONCLUSION

In this unit, we have considered general housing standards (floor, cubic space, walls, etc.), various housing indicators (physical, economic and social), overcrowding, housing in Nigeria and policies as well as health effects of poor housing such as respiratory illnesses, skin problems, mortality etc.

5.0 SUMMARY

In this unit we have learnt that:

- Housing refers to houses or buildings collectively; accommodation of people; planning or provision of accommodation by an authority.
- Housing is an important determinant of health and substandard housing is a major public health issue.
- Housing standards depend on conventional factors such as per capita space and floor space and on social and economic characteristics such as; family income, family size and composition, standard of living, life style, stage in life cycle, education and cultural factors.
- There are typical housing standards for site, walls, windows, floor, etc.
- The indicators of housing include; physical, economic and social indicators.
- the National Housing Fund and an Infrastructural Development Fund have been put in place to facilitate the attainment of the goals of sustainable human settlement in the country.
- Some health effects of poor housing include; respiratory problems, skin diseases, accidents, mortality, etc.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe five housing standards.
2. What is overcrowding?
3. List five health effects of poor housing.

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UNIT 2 RECREATIONAL HEALTH

CONTENTS

1.0 INTRODUCTION

Humans spend their time in activities of daily living, work, sleep, social duties and recreation. Recreational activities can be communal or solitary, active or passive, outdoors or indoors, healthy or harmful and useful for society or detrimental. Examples of recreational activities could include swimming, hiking, reading, playing or listening to music, watching movies or TV, gardening, hunting, sports, studies and travel. Public space such as parks, zoological and botanical gardens, swimming pools and beaches are essential venues for many recreational activities as well as high risk areas of public health concern. It is therefore important to access recreational environments in order to ensure human health and safety during recreation.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss health risks associated with recreational environments
- discuss guidelines associated with safety in recreational environments
- discuss safety measures for recreational environments.

3.0 MAIN CONTENT

3.1 Recreational Water Environment

Recreational water can be in form of swimming pools, hot tubs, whirlpools, spa pools and plunge pools. Swimming pools and other recreational water environments may be located either outdoors or indoors. They may be supplied with potable or marine water, supervised or unsupervised and heated or unheated.

3.1.1 Health Risks Associated with Recreational Water Environments

The recreational water environment presents a considerable risk because it can both amplify the concentration of the hazard and facilitate exposure of humans. The presence of organic matter and elevated temperatures associated with many recreational water environments can provide an environment suitable for the proliferation of opportunistic pathogens that can infect mucous membranes, lungs, skin and wounds. These health risks include;

Physical risks: The most immediate and severe danger arises from accidental drowning. Another source of harm is injuries, potentially serious or even fatal, that can arise from slipping and tripping or from becoming snagged in ropes and fences or fittings such as ladders and drains. There have even been cases where swimmers have been thrown clear of the pool onto hard surfaces in heavy seas.

Infectious Diseases: A number of infectious diseases can be acquired in swimming and spa pools that can cause diarrhoea or skin, ear, eye and upper respiratory infections. Hot tubs and whirlpools and associated equipment can create an ideal habitat for the proliferation of bacteria such as *Legionella* and *Mycobacterium* spp. In addition, *Pseudomonas aeruginosa* is frequently present in whirlpools, and skin infections have been reported when pool design or management is poor. Pathogens transmitted by the faecal–oral route have commonly been associated with swimming and spa pools. Contamination occurs when pathogens enter with human sewage or animal faecal contamination or are released directly by infected bathers. One of the most important such pathogens is *Cryptosporidium* spp., which have infectious oocysts that are resistant to even the highest levels of chlorine that are generally used for maintaining residual disinfection in pools. Infections of surfaces such as skin and ears have been associated with spa pools where disinfection has been inadequate. These infections arise from opportunistic pathogens that are commonly present in water and soils.

3.1.2 Recreational Water Safety and Guidelines

According to the World Health Organization (2006), there are three guidelines for maintaining a safe recreational water environment such as swimming pools, spas, etc. They include; design and operations, pool hygiene and monitoring.

3.1.2.1 Design and Operation

The pool and its water supply need to be designed, constructed and operated in view of the health and safety protection of bathers. These design, construction and operational issues are summarized as follows;

Circulation and hydraulics: It is essential that treated water reaches all parts of the pool and polluted water needs to be removed (especially from areas most used and most polluted by users). If not, even good water treatment may not result in good water quality. The design and positioning of inlets, outlets and surface water withdrawal are important. Pools usually use water supply passing through an air gap or backflow preventer. The fill level of the pool is at the skim gutter level. The pool overflows can either be directed by gravity to the make-up tank for recirculation through the filter system or disposed off as waste. Circulation rate is related to turnover period, which is the time taken for a volume of water equivalent to the entire pool water volume to pass through the filters and treatment plant and back to the pool. In principle, the shorter the turnover period, the more frequent the pool water treatment. Turnover periods need to suit the particular type of pool.
The design of a swimming pool should recognize the need to dilute the pool water with fresh water. Dilution controls the accumulation of pollutants from users (e.g. constituents of sweat and urine), the by-products of disinfection and various other dissolved chemicals and pollutants. A drain must also be installed at the lowest point in the pool, and drainage facilities need to be sufficient to ensure quick emptying. The drains from the pool should be independent; however, when they are connected to any other drainage system, a backwater valve must be installed in the recreational water environment to prevent cross-connections. Anti-vortex and anti-entanglement type drain covers must be provided, which are constructed of durable, easily visible and readily cleaned material.

Bather load: Bather load needs to be considered and prepared for during both design and operation of pools. The circulation and treatment systems and the hydraulic volume will determine the appropriate safe bather load.

Filtration: Filtration is important to good water quality, affecting both aesthetic clarity and disinfection. Disinfection will be compromised by reduced clarity, as particles associated with turbidity can surround microorganisms and shield them from the action of disinfectants. In addition, filtration is important for removing *Cryptosporidium* oocysts and *Giardia* cysts and some other protozoa that are relatively resistant to chlorine disinfection.

Filters need to be designed to remove particles at a sufficient rate, such as removing all particles greater than 10 µm from the entire volume of the pool in 6 hours or less. Filters can be cartridge or media type (e.g. rapid-pressure sand filters, high-rate sand filters, diatomaceous earth filters or gravity sand filters). All media-type filters need to be capable of being backwashed. Filter accessories, such as pressure gauges, air-relief valves and rate-of-flow indicators, should be provided as required. Sufficient access to sand filters should be maintained so that they can be inspected at a regular frequency, at least on a weekly basis, and the media must be changed periodically.

Coagulants (and flocculants) enhance the removal of dissolved, colloidal or suspended material by bringing this material out of solution or suspension as solids (coagulation), then clumping the solids together (flocculation), producing a floc, which is more easily trapped in the filter. Coagulants are particularly important in helping to remove the infective cysts of *Giardia* and oocysts of *Cryptosporidium* spp., which otherwise would pass through the filter. Coagulant efficiency is dependent on pH, which therefore needs to be controlled. Dosing pumps should be capable of accurately dosing the small quantities of coagulant required and adjusting to the requirements of the bather load. Coagulation is often required as a prerequisite to effective filtration, depending on the filtration process selected.

Disinfection: Disinfection is a process whereby pathogenic microorganisms are removed or inactivated by chemical (e.g. chlorination) or physical (e.g. filtration, UV radiation) methods, such that they represent no significant risk of infection. Recirculating pool water is disinfected using the treatment process and the entire water body is disinfected by application of a disinfectant residual, which inactivates agents added to the pool by users.

For disinfection to occur with any biocidal chemical, the oxidant demand of the water being treated must first be satisfied and sufficient chemical must remain to effect disinfection. Common disinfectants include; chlorine, UV radiation and ozone.
Issues to be considered in the choice of a disinfectant and application system include:

- safety;
- comfort (e.g. avoiding skin irritation);
- compatibility with the source water (hardness and alkalinity);
- type and size of pool (disinfectant may be more readily degraded or lost through evaporation in outdoor pools);
- oxidation capacity;
- bather load (sweat and urine from bathers will increase disinfectant demand);
- operation of the pool (i.e. supervision and management).

The choice of disinfectant used as part of recreational water treatment should ideally comply with the following criteria:

- effective, rapid inactivation of pathogenic microorganisms;
- capacity for ongoing oxidation to assist control of contaminants during pool use;
- a wide margin between effective biocidal concentration and the concentration resulting in adverse effects on human health;
- availability of a quick and easy determination of the disinfectant's concentration in pool water (simple analytical and test methods);
- potential to measure the disinfectant's concentration electrometrically to permit automatic control of disinfectant dosing and continuous recording of the values measured.

Air quality: It is important to manage air quality as well as water quality in recreational water environments. Rooms housing recreational water should be well ventilated to avoid an accumulation of *Legionella* spp. in the indoor air. In addition, ventilation will help reduce exposure to disinfection by-products in the air. Adequate ventilation should reduce risks from *Legionella* spp., but it is important that the system does not create its own risks

3.1.2.2 Pool Hygiene

Pre-swim showering: Pre-swim showers will remove traces of sweat, urine, faecal matter, cosmetics, suntan oil and other potential water contaminants. The result will be cleaner pool water, easier disinfection using a smaller amount of chemicals and water that is more pleasant to swim in. Pre-swim showers should be located adjacent to the swimming pool and be provided with water of drinking water quality, as children and some adults may ingest the shower water. Shower water must run to waste.

Visiting toilets pre-swim: Toilets must be provided where they can be conveniently used before entering the pool and after leaving the pool. Users should be encouraged to use the toilets before bathing to minimize urination in recreational waters. Parents need to encourage children to empty their bladders before they swim. Children below a certain age, such as below two years old, may not be permitted to use some pools.

Vomitus and Accidental Faecal Releases (AFRs): It is necessary to minimize AFRs and vomitus and to respond effectively to them when they occur. AFRs appear to occur relatively frequently and it is likely that most go undetected. A pool operator faced with an AFR or vomitus in the pool water needs to act immediately. If a faecal release is a solid stool, it can simply be retrieved quickly and discarded appropriately. The scoop used to retrieve it must be disinfected so that any bacteria and viruses adhering to it are inactivated and will not be returned to the pool the next time the scoop is used. As long as the pool is in other respects operating properly (disinfecting residuals, etc.), no further action is necessary. If the stool is runny (diarrhoea) or if there is vomitus, the situation is potentially hazardous. Even though most disinfectants deal relatively well with many bacterial and viral agents in AFRs and vomitus, the possibility exists that the diarrhoea or vomitus is from someone infected with one of the protozoan parasites, *Cryptosporidium* and *Giardia*. The infectious stages (oocysts/cysts) are relatively resistant to chlorine disinfectants in the concentrations that are practical to use.
The pool must therefore be cleared of users immediately. The safest action, if the incident has occurred in a small pool, hot tub or whirlpool, is to empty and clean it before refilling and reopening. However, this may not be possible in larger pools. If draining down is not possible, then the procedure given below can be followed:

- The pool is cleared of people immediately.
- Disinfectant levels are maintained at the top of the recommended range.
- The pool is vacuumed and swept.
- Using a coagulant, the water is filtered for six turnover cycles. This could take up to a day and so might mean closing the pool until the next day.
- The filter is backwashed (and the water run to waste).
- The pool is reopened.

3.1.2.3Monitoring

The following parameters; turbidity, disinfectant residual and pH must be monitored frequently and in all pool types.

Turbidity: A turbidity limit of 0.5 nephelometric turbidity unit (NTU), or equivalent measurement, provides a good target value for well-treated water. Any value exceeding turbidity limits suggests both a significant deterioration in water quality and a significant health hazard.

Disinfectant levels and pH: For a conventional public swimming pool with good hydraulics and filtration, operating within its design bather load, adequate routine disinfection should be achieved with a free chlorine level of 1 mg/l throughout the pool. In a well-operated pool, it is possible to achieve such a residual with maximum levels at any single point below 2 mg/l for pools. Lower residuals (0.5 mg/l) will be acceptable in combination with the additional use of ozone or UV disinfection, whereas higher levels (ranging from 2 to 3 mg/l) may be required for hot tubs, because of higher bather loads and higher temperatures.

Disinfectant residuals must be checked by sampling the pool before it opens and during the opening period (ideally, during a period of high user load). The frequency of testing during swimming-pool use depends on the nature and use of the swimming pool. Samples should be taken at a depth of 5–30 cm. It is good practice to include as a routine sampling point the area of the pool where the disinfectant residual is lowest. Occasional samples should be taken from other parts of the pool and circulation system. If the routine test results are outside the recommended ranges, the situation needs to be assessed and action taken.

The pH value of swimming-pool water needs to be maintained within the recommended range to ensure optimal disinfection and coagulation. The pH should be maintained between 7.2 and 7.8 for chlorine disinfectants and between 7.2 and 8.0 for bromine-based and other non-chlorine disinfection processes. In order to do so, regular pH measurements are essential, and either continuous or intermittent adjustment is usually necessary.

Microbial quality: Samples of pool water from public pools should be monitored at appropriate intervals for microbial parameters, including thermotolerant coliforms or *E. coli*, *Pseudomonas aeruginosa*, *Legionella* spp. and *Staphylococcus aureus*. The frequency of monitoring and the guideline values vary according to microbial parameter and the type of pool.

Where operational guidelines are exceeded, pool operators should check turbidity, residual disinfectant levels and pH and then resample. When critical guidelines are exceeded, the pool should be closed while investigation and remediation are conducted.

The following monitoring of microbial quality is recommended:

- Thermotolerant coliforms and *E. coli* are indicators of faecal contamination. Either thermotolerant coliforms or *E. coli* should be measured in pools, hot tubs and spas. Operational levels should be less than 1 cfu or 1 most probable number (mpn) per 100 ml.
- Routine monitoring of *Pseudomonas aeruginosa* is recommended in hot tubs and spas. It is suggested for swimming pools when there is evidence of operational problems (e.g. failure of disinfection or problems relating to filters or water pipes), a deterioration in the quality of the pool water or known health problems. It is recommended that, for continuously disinfected pools, operational levels should be below 1 cfu/100 ml. If high counts are found (>100 cfu/100 ml), pool operators should check turbidity, disinfectant residuals and pH, resample, backwash thoroughly, wait one turnover and resample. If high levels of *P. aeruginosa* remain, the pool should be closed, and a thorough cleaning and disinfection programme should be initiated. Hot tubs should be shut down, drained, cleaned and refilled.
- Periodic testing for *Legionella* spp. is useful, especially for hot tubs, in order to determine whether filters are being colonized. It is recommended that operational levels should be below 1 cfu/100 ml. Where this is exceeded, hot tubs should be shut down, drained, cleaned and refilled. Shock chlorination may be appropriate if it is suspected that filters have become colonized.
- Routine monitoring of *Staphylococcus aureus* is not recommended, although monitoring may be undertaken as part of a wider investigation into the quality of the water when health problems associated with the pool are suspected. Where samples are taken, levels should be less than 100 cfu/100 ml.

3.2 Zoological Parks

A zoological garden or zoological park is a facility in which animals are housed within enclosures, displayed to the public, and in which they may also breed. Zoo animals live in enclosures that often attempt to replicate their natural habitats or behavioral patterns, for the benefit of both the animals and visitors. Some zoos have walk-through exhibits where visitors enter enclosures of non-aggressive species, such as lemurs, marmosets, birds, lizards, and turtles. Zoos can take the following forms;

Safari Parks: Some zoos keep animals in larger, outdoor enclosures, confining them with moats and fences, rather than in cages. Safari parks,

also known as zoo parks allow visitors to drive through them and come in close proximity to the animals.
Public Aquaria: Public aquaria are the aquatic counterpart of a zoo, which houses living aquatic animal and plant specimens for public viewing.

3.2.1 Zoo Worker Safety

Zoo keepers are in charge of cleaning, feeding, and care of animals. These activities present a level of risk. Personal protective equipment (PPE) is essential in these tasks. Examples of PPE used by zoo workers are masks, gloves, boots, goggles, and communication devices. Techniques and specialized equipment also contribute to zoo worker safety. When needing to transport or care for animals, basic capture and restraint equipment varies by animal. Equipment commonly used includes gloves, nets, blow darts, projectile guns/darts, and crates or cages. There are health risks associated with working in Zoos. Some of them include;

Respiratory-related illness and disease: such as asthma and allergies.
Venoms and Toxins: another potential hazard for zoo employees is for those who work with venomous animals. These animals have bites or stings that expose the victim to a toxin. Many of the reptiles in zoos are exotic and poison control centers may not keep the appropriate anti-venom in stock.

Common Injuries: Other common injuries include needlestick injuries, radiation exposure from x-rays and animal related injuries such as bites and kicks.

Chemical Exposure: there is a risk for chemical exposure due to anesthetic agents, formaldehyde, pesticides and disinfectants.

Zoonotic Diseases: Zoonotic diseases, otherwise known as zoonosis, are diseases that can be transferred from animals to humans and vice versa. They can be spread through the air, through common animal vectors (such as animals), or through direct contact. Within zoos, the most susceptible group for contracting a zoonotic disease is zoo workers such as veterinarians and zookeepers who have direct contact with the animals. The most commonly known zoonotic diseases are West Nile, Avian influenza, Salmonella and Escherichia coli. Other, less known diseases that can be spread between humans and animals are tuberculosis and Human Immunodeficiency Virus (HIV) most often found as retroviruses in animals.
The design and structure of the zoo enclosures limits the exposure of zoonotic diseases to guests and workers by limiting exposure and direct

contact to the animals. Using personal protective equipment properly, examining animals on a regular basis and reporting new illnesses and outbreaks to proper authorities as well as providing extensive education and training on how to properly handle and care for animals are all important components of limiting zoonotic disease transmission.

3.2.2 Zoo Visitor Safety

Proper enclosure design is the best method to protect zoo guests from animal exposures. Proper enclosure designs include construction of some of the following;

Dry moats: are built by digging a deep trench around a section or the entirety of the exhibit that is wide enough to prevent an animal from jumping across. Signs and railings are used to prevent guests from climbing into the exhibit or falling into the moat.

Wet moats: are similar to dry moats with the exception that they are filled with water and often built to resemble naturally occurring bodies of water such as a river. However, unless the water is circulated and filtered, wet moats have the potential to become habits for mosquitoes and other disease spreading entities.

Glass barriers: they prevent allergens and zoonotic diseases from passing between the guest and the animal because they restrict the flow of air and provide a physical barrier to objects crossing into or out of the exhibit. However, glass requires cleaning on both sides of the exhibit and might expose staff to diseases or physical hazards unless additional safety measures are taken.

Fences: they are most often designed so that pressure placed upon them by the animal does not damage the integrity of the fence. The exact type of fencing used depends on the species being housed in the exhibit. “Apron fencing” or fencing that extends underground is used to enclose species that can dig. “Overhang fencing”, or fencing that curves towards the inside of the exhibit at the top is used to enclose species that can jump or climb.

Safety signage and security staff: is primarily responsible for detouring unsafe behaviors such as standing on barriers and avoiding potential tripping hazards and furthermore, the presence of zoo security staff, guest services and zookeepers may help limit potentially hazardous situations for guests.

4.0 CONCLUSION

In this unit, we have been able to learn about different recreational environments and the various health risks associated with them which includes zoonotic infections, venoms and toxins, injuries etc. We have also been able to look into recreational water guidelines and safety of zoo workers and visitors' safety.

5.0 SUMMARY

In this unit we have learnt that:

- Recreational water can be in form of swimming pools, hot tubs, whirlpools, spa pools and plunge pools.
- The recreational water environment presents a considerable risk because it can both amplify the concentration of the hazard and facilitate exposure of humans.
- Recreational water environments are places of high physical and infectious disease risks.
- According to the World Health Organization (2006), there are three guidelines for maintaining a safe recreational water environments such as swimming pools, spas etc. They include; design and operations, pool hygiene and monitoring.
- A zoological garden or zoological park is a facility in which animals are housed within enclosures, displayed to the public, and in which they may also breed.
- There are health risks associated with working in Zoos. Some of them include; respiratory illnesses, zoonotic diseases, injuries etc.
- Proper enclosure design is the best method to protect zoo guests from animal exposures.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain health risks associated with recreational water environments.
2. Explain health risks associated with zoo workers.

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UNIT 3 WORKPLACE HAZARDS AND HEALTH

CONTENTS

1.0 INTRODUCTION

Workers are exposed to various hazards in the course of earning their living. These hazards can sometimes result in harmful situations that may even cause permanent injury or death to the worker. Thus, the work environment should be set up and assessed in order to ensure the health and safety of workers.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- define and explain hazards
- discuss different types of hazards
- explain risk assessment.

3.0 MAIN CONTENT

3.1 Hazards

A hazard is a condition or an event that can cause harm if not controlled. The harm is the outcome that results from an uncontrolled hazard. A risk is a combination of the probability that a particular outcome will occur and the severity of the harm involved. Although work provides many economic and other benefits, a wide array of workplace hazards also present risks to the health and safety of people at work. These include but are not limited to; chemicals, biological agents, physical factors, adverse ergonomic conditions, allergens, a complex network of safety risks and a broad range of psychosocial risk factors.

Physical Hazards: Physical hazards affect many people in the workplace. Machines have moving parts, sharp edges, hot surfaces and other hazards with the potential to crush, burn, cut, shear, stab or wound workers if used unsafely. Falls are also a common cause of occupational injuries and fatalities, especially in construction, extraction, transportation, healthcare, and building cleaning and maintenance.

Biological hazards (biohazards): include infectious microorganisms such as viruses and toxins produced by those organisms. Biohazards affect workers in many industries. Outdoor workers, including farmers, landscapers, and construction workers, risk exposure to numerous biohazards, including animal bites and stings, toxins from poisonous plants and diseases transmitted through animals. Health care workers, including veterinary health workers, risk exposure to blood-borne pathogens and various infectious diseases especially those that are emerging.

Chemical Hazards: Dangerous chemicals can pose hazards in the workplace. There are many classifications of hazardous chemicals, including neurotoxins, immune agents, dermatologic agents, carcinogens, reproductive toxins, systemic toxins, asthmagens, pneumoconiotic agents, and sensitizers. There is some evidence that certain chemicals are harmful at lower levels when mixed with one or more other chemicals. This may be particularly important in causing cancer. Regulatory agencies set occupational exposure limits to mitigate the risk of chemical hazards.

Psychosocial hazards: Psychosocial hazards include risks to the mental and emotional well-being of workers, such as feelings of job insecurity, long work hours, and poor work-life balance.

3.2 Risk assessment

Hazard analysis is an important step in the overall risk assessment and risk management process. It is where individual work hazards are identified, assessed and controlled/eliminated as close to source (location of the hazard) as reasonably as possible. In some climes, risk assessment is required by legislation before interventions are carried out.

This assessment should:

- Identify the hazards
- Identify all affected by the hazard and how
- Evaluate the risk
- Identify and prioritize appropriate control measures

The information that needs to be gathered from sources should apply to the specific type of work from which the hazards can come from. Examples of these sources include interviews with people who have worked in the field of the hazard, history and analysis of past incidents and official reports of work and the hazards encountered. Of these, personnel interviews may be the most critical in identifying undocumented practices, events, releases, hazards and other relevant information. The assessment should be recorded and reviewed periodically and whenever there is a significant change to work practices. The assessment should include practical recommendations to control the risk.

4.0 CONCLUSION

In this Unit, we have considered different types of workplace hazards; physical, chemical, biological and psychosocial. Risk assessment includes; identifying hazards and all workers affected, evaluate the risk and carry out appropriate controls.

5.0 SUMMARY

In this unit we have learnt that:

- A hazard is a condition or an event that can cause harm if not controlled. The harm is the outcome that results from an uncontrolled hazard.
- Machines have moving parts, sharp edges, hot surfaces and other hazards with the potential to crush, burn, cut, shear, stab or wound workers if used unsafely.
- Biohazards include infectious microorganisms such as viruses and toxins produced by those organisms.
- Dangerous chemicals can pose hazards in the workplace.
- Psychosocial hazards include risks to the mental and emotional well-being of workers, such as feelings of job insecurity, long work hours, and poor work-life balance.
- Hazard analysis is an important step in the overall risk assessment and risk management process.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are hazards?
2 Explain the types of hazards.
3. What is risk assessment?

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MODULE 5 ENVIRONMENTAL HEALTH ETHICS, LAW AND GOVERNANCE

UNIT 1 ENVIRONMENTAL HEALTH ETHICS, CODE OF CONDUCT AND PRACTICE

CONTENTS

1.0 INTRODUCTION

Different schools of thoughts have argued over environmental health issues and each have tried to take a moral standpoint in arguing its views. It is often difficult to take sides in such instances and as such there arose a need for a common set of rules or morals that will guide environmental health practitioners and the society at large in maintaining a healthful environment. As we progress in this unit, you will understand what "ethics" is all about and the general guiding principles of environmental health as well as some ethical principles guiding environmental health practitioners locally.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the term “ethics”
- understand the general principles of environmental health ethics
- identify ethical principles for environmental health practitioners in Nigeria
- discuss the controversies around environmental health ethics

3.0 MAIN CONTENT

3.1 What is Ethics?

Ethics can be defined most readily by contrasting it with morals. Morals, or morality, is the set of core beliefs or commitments of a person or society that identifies what is most important, valuable, or right with regard to conduct and character. Ethics refers to a more formal version of morality. Ethics can mean a reasoned or systematic approach to figuring out what is the right or wrong thing to do or to stand for. Ethics is essentially a connecting or interpretive vocabulary that helps us understand our daily actions in the light of a larger picture of society and the world around us. So, when we use an ethical concept such as justice, we may refer to a single fair action by an individual, a nationwide project to reduce health disparities, an initiative to reduce international debt, or even a belief that the universe keeps all events in harmony.

Ethical codes are valuable and should be read and consulted often. Their main purpose is to indicate the general direction of professional purpose and commitment and to express professional idealism while at the same time setting criteria that define minimal standards of conduct. So an idealistic environmental health professional could for instance, use such a code to support championing tighter limits on the release of particulates into the air while a licensing board could refer to the same code when criticizing a professional who accepted bribes in order to suppress health data potentially costly to an industry.

The environmental health professions are diverse and in the process of acquiring a common sense of identity, and so environmental health ethics, as a unified concept, is in formation and draws on a wide variety of sources. Reflection on environmental health and ethics has an ancient history. In classical times, scholars reflected on the relationship of humans to the earth and debated the extent to which the earth was created to provide its bounty for human welfare and the extent to which humans have a responsibility to perfect nature for human use. Medieval reflection considered whether environmental damage to the earth resulted from human actions and early modern reflection considered the prospects for human dominance over nature as science and industry entered their early years.

3.2 General Principles of Environmental Health Ethics

Most environmental health work involves population health and the relationships of populations to the environment. And so, environmental health ethical principles tend to emphasize general ecological and population impacts rather than immediate and individual impacts. Accordingly, environmental health ethics is slightly different from traditional individual-centered professional ethics. Environmental health ethics are illustrated by some principles outlined below;

Sustainability

A concern for sustainability has three immediate implications for environmental health practice. First, methods of cost accounting that discount future risks must be reconsidered. Discounting tends to diminish the significance of events a few decades ahead to nothing, when in fact they are significant and may become irremediable unless we take present action. Second, the full life cycle cost of environmental health measures must be considered. So, for example, if a city or industry plans to build a sewage plant, it must consider not only local health benefits but also the carbon cost to the atmosphere of fuel expenditures to process the sewage and the environmental costs of mining and harvesting materials, producing energy, and shipping in order to build the plant in the first place. Third, many have observed a strong correspondence between the wealth of a nation and the average health of its citizens. However, if in maintaining the current welfare of its population, a nation overburdens its environment or the environments of other nations and of the globe, that nation will undermine everyone's health in the long run.

Healthfulness

We should think not just of improving human health but of improving human health in the setting of a healthy global environment. Healthy ecosystems are necessary to maintain human health in the long run. Thus the use of such toxic substances as cleaners, pesticides, and herbicides poses a dilemma for environmental health practice. Although these substances may protect human health in the short run, they are likely in the long run to damage the environment. So, in addition to their indirect toxic effects on humans, their impact on the environment can also harm human health in the long run. Moreover, we should think in terms of the restoration of human and environmental health. In many parts of the world, human and environmental health are declining in tandem. For example, Africa bears the cost of many of the environmental practices of the developed nations and has fallen to radically low levels of environmental health. Some island nations are experiencing hurricanes, floods, and chronic salinization of agricultural and forest land due to climate change.

Interconnection

A strong sense of interconnection does not so much constitute a rule of ethical rightness and wrongness as it speaks to the basic concept of moral responsibility. This importance of a strong sense of responsibility has been greatly amplified by our increasing understanding of the earth as a coherent ecological system. For many in the environmental movement, this is largely expressed by awareness of the strong biological and physical interconnections of earth's ecosystems such as; carbon released from smokestacks in the Northern Hemisphere spreads to the Southern Hemisphere and toxic chemical pollutants, such as dioxins, can be found in the ice and snow of polar regions. This led to one of the important achievements in environmental health in recent decades which was the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer, which limited the use of chlorofluorocarbons (CFCs) and other chemicals damaging to stratospheric ozone.

Global Equity

Humans are basically interconnected on a limited planet and have roughly equal needs and capacities, it is difficult to justify anything but equal access to basic resources, especially those in the global commons, such as the atmosphere, the oceans, our genetic heritage, and the wilderness. Inequality is harmful to public health. Stratified societies excite envy, hinder self-expression, and tend to create conditions so limited that some of us are unable to meet basic health needs. Thus among developed nations the average level of public health corresponds less to the average level of wealth than to the average level of economic equality. Over-privileging one group in relationship to another is probably unhealthy for both groups. For the group left in poverty the environmental health risks are obvious. But for the wealthy there are the risks of obesity, overconsumption, inactivity, anxiety, and so on. Equality, even apart from its ethical strength, is a public health measure.

Respectful Participation

Those with and for whom environmental health professionals work need to participate in the decisions of environmental health professionals. We can generalize about common human health needs, but individuals and organizations have widely varying, and sometimes myopic, interpretations of their own environmental health needs. This presents difficulties for environmental health professionals asked by their clients to support unwise choices. Perhaps the problem of disagreement with patients, employers, and stakeholders is best resolved through the concept of leadership. When consulted, a professional with environmental health expertise is expected to lead others to what the profession would recommend as the healthiest course of action. However, leadership must be balanced. One key way to reconcile potential conflicts between individual choices and professional recommendations is to press for the right to know. Although the principle of the right to know takes many forms, its main thrust is to urge that people who are affected by environmental hazards and toxins should be made aware of the nature of the risks to which they are exposed.

3.3 Environmental Health Code of Conduct and Practice in Nigeria

A code of conduct is a set of rules outlining the social norms, responsibilities and proper practices for an individual, party or organization. It is also sometimes referred to as "Code of Ethics". A Code of Conduct aids in establishing an inclusive culture in an organization. An ethical culture is created by the leadership of an organization who manifest their ethics in their attitudes and behavior. The Environmental Health Officers Registration Council of Nigeria (which is established by Act 11 of 2002) provides a Code of Professional Ethics (Section 27) which all Environmental Health Officers in Nigeria are expected to abide by. Some of these principles include (EHORECON, 2015);

- Improving the environment and public health
- Maintenance of a high level of competence
- Maintaining integrity
- Confidentiality of Information
- Adherence to the highest standards of personal ethics
- refusal to participate in unethical procedures and processes
- protection of the public from harm

3.4 Controversies in Environmental Health Ethics

Because environmental and health concerns are involved in most human activities, many ethical questions, dilemmas and controversies arise in environmental health ethics. A few general observations can be made, however, about similarities among these controversies. Ethical doubts, dilemmas, and struggles tend to arise when the following elements are present:

New technologies with uncertain risks: It is known that new technologies are likely to bring with them unexpected effects. People may reasonably differ over whether the risks are known, whether they can be well managed, and whether those developing the technology can be trusted.

Social relationships with expectable conflicts: Confidentiality, informed consent, and environmental justice problems all arise from controversies over respectful treatment of others. These problems are by no means confined to environmental health issues.

The rational balancing of risks and benefits: Some of these debates involve disagreements over the value of activities. Some of the debates are simply over how to weigh risks rationally: How much more important is safety and avoiding harm than finding new ways to benefit people? And mistrust among groups with different interests makes it difficult to rely on common estimates of risks.

Competing goods: Health is one of many goods. All environmental health discussions must take place in the context of commitments to other values, some of which are difficult to harmonize with health.

Cultural differences: Different geographic locations tend to expose people to different environmental risks. So, understanding each other's needs across cultures can be challenging.

Because most environmental health issues involve a community of people and the natural world, there will inevitably be many people involved in ethical disputes in this arena. This means that environmental health professionals need to work respectfully and persistently with others to achieve the environmental health ideals for which they stand. Because the natural world is in decline and maintaining human population health globally is becoming more challenging, environmental health professionals occupy an increasingly important place in the world and need to speak out clearly and actively for their professions' ethical ideals.

4.0 CONCLUSION

We have learnt in this unit, that ethical codes provide general direction of professional purpose and commitment and to express professional idealism while at the same time setting criteria that define minimal standards of conduct. Environmental health ethics focuses on ecological and population impacts and is guided by some principles such as, sustainability, healthfulness, interconnectedness, global equity and respectful participation. Controversies occur in environmental health ethics due to various because most environmental health issues involve a community of people and the natural world.

5.0 SUMMARY

In this unit we have learnt that:

- Ethics can mean a reasoned or systematic approach to figuring out what is the right or wrong thing to do or to stand for.
- The environmental health professions are diverse and in the process of acquiring a common sense of identity, and so environmental health ethics, as a unified concept, is in formation and draws on a wide variety of sources.
- Environmental health ethics are illustrated by some principles such as; sustainability, healthfulness, interconnectedness, global equity and respectful participation.
- A code of conduct is a set of rules outlining the social norms, responsibilities and proper practices for an individual, party or organization.
- The Environmental Health Officers Registration Council of Nigeria (which is established by Act 11 of 2002) provides a Code of Professional Ethics (Section 27) which all Environmental Health Officers in Nigeria are expected to abide by.
- Because environmental and health concerns are involved in most human activities, many ethical questions, dilemmas and controversies arise in environmental health ethics.
- Environmental health professionals need to work respectfully and persistently with others to achieve the environmental health ideals for which they stand.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define ethics.
2. Explain three principles of environmental health ethics.
3. List three principles environmental health officers are expected to abide by.
4. Explain three controversies of environmental health ethics.

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UNIT 2 ENVIRONMENTAL HEALTH POLICY

CONTENTS

1.0 INTRODUCTION

Anthropogenic activities on the environment, affect human health and can lead to adverse health conditions among individuals and populations. It is imperative that some actions are taken to tackle this problem especially at governmental levels where leadership is provided for populations. However, governments cannot take actions unless policies are developed towards this problem. This unit will seek to make you understand the links between the environment, health and policy and also examine some policies in developing countries as well as policies developed international settings.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the concept of environmental health policy
- discuss some environmental health policies of developing countries
- discuss some environmental health policies at the international level.

3.0 MAIN CONTENT

3.1 Concept of Environmental Health Policy

Environmental health policy refers to the interplay between the environment and health, and how the environment can affect human health. Policies are created by governments and organizations where they see the issues arising in the health of their jurisdiction related to the environment.

There are several environmental factors that can contribute to health including air quality, climate change, toxic drinking water, and toxic chemical exposure. Depending on the region the policy is in, different environmental factors are going to be addressed in the policy. Some effects of the environment on health can include asthma, malaria, cholera, disease, cancer, and physical injury. These are also dependent on the area in which the individual lives, and how severe the environmental factors are. Climate change issues have become more prevalent in the 21st century, requiring action from global leaders. When there are substantial changes to the environment, a populations health is vulnerable to potential risks.

Environmental Health Policy can be implemented at many levels of government, including the community, state and international levels. Community governments focus on policies that affect the boundaries they control, while state governments focus on several cities or states within their borders where environment affects health. International policies involve the cooperation of several states to implement the same policy to address larger environmental issues on health like pollution and climate change.

Developing nations do not always have the same access to resources to implement policies that can improve the environment and health of their citizens. Environmental factors can have an unequal impact on lower income and ethnic minority regions being exposed to environmental stressors and a lower quality of life. As such developing nations take a different approach to environmental health politics than developed nations.

When defining environmental health policy, it is best to break down the concept into three separate groups; environment, health and policy. The environment aspect of the term refers to the ecosystems and the environmental factors that can impact human health. Health refers to the human being's ability to function successfully when environmental factors are constantly changing. In its more simplistic definition, health is the overall well-being of a person. Policy is a "course of action or principle adopted or proposed by a government, party, business, or individual". Thus, environmental health policy refers to the human impact on the environment, which in turn has an impact on human health and requires policy action.

3.2 Environmental Health Policies in Developing Countries Nigeria

In 2014, Nigeria implemented the World Health Organization Country Cooperation Strategy to deal with Millennium Development Goals. A strategic objective of the policy was to assess health impacts of environmental risks by conducting health impact assessments. The government also plans to increase the country's abilities to deal with environmental emergencies including climate change, air pollution, and radiation that could be harmful to health. The strategy focuses on creating policies that result in reduction in diseases caused by the environment.

India

In the mining communities of India, the population is at risk of respiratory illness and malaria. Those who live closer to the mines reported higher incidences of these illnesses. This has influenced environmental policy because mining is a profitable business that can be privatized, but with adverse effects on health they have been required to balance human and ecological health. India has also seen difficulty providing access to drinking water and sanitation services in rural areas. Community demand-driven programmes have been implemented since 2004 which required improvements in water supply, sanitation, and hygiene. This was an effort to improve children's health, and reduce diarrhoea and water-related illnesses. Only 21% of the rural population was using a private tap, the other percentage commuted to obtain water. Only 12% used private toilets, the others travelled to a main sanitation site. The implemented program was able to increase access to filtered water, private toilets, and increased hygiene.

Kenya

In 2016, the Kenya government introduced the new Kenya Environmental Sanitation and Hygiene Policy. Poor sanitation has been a leading cause of mortality in the country. The new policy created a timeline from 2016-2030 in which guidelines were set for state and non-state actors to follow to improve sanitation and create a better quality of life. The aim is to have universal access to sanitation by 2030. This includes all public places and dwellings having access to sustainable toilets, free from odours, and reducing hygiene related diseases. Air pollution in urban centres is also a concern. In Nairobi, pollution levels are three times higher than World Health Organization recommendations. Urbanization is projected to increase in the next decade, so the government has created Kenya Vision 2030 in attempts to deal with sanitation practices in the country. Kenya Visions wants to make Kenya a newly industrialized, middle-income country with a high quality of life for its citizens.

3.3 Environmental Health Policies at International level World Health Organization (WHO)

The World Health Organization studies the effects and supports the design of preventative and health strategies in countries to reduce environmental health risks. Environmental factors such as air and water quality, patterns of energy use, and patterns of land use can directly and indirectly affect health of citizens. The WHO has also acknowledged that diseases such as diarrhea, respiratory infections, malaria, and unintentional injuries among others can be caused by environmental factors that could be modified by policy. WHO has always supported the United Nation's Millennium Development Goals to provide sustainable access to safe drinking water. The benefits to the MDG's is savings in health care, economic productivity, and fewer lives lost from diseases caused by contaminated water.

United Nations

In year 2000, the Millennium Development Goals (MDG) were created at the UN Millennium Declaration. Eight goals were created in order to deal with extreme poverty due to climate, shelter, and disease, and ensure everyone has the right to health, education, shelter, and security. Sustainable Development Goals (SDG) were created to replace the MDG's, which are to be reached by 2030. These goals are aimed at both developing and developed countries, using environmental, social, and economic dimensions to meet goals. Goals 3, 6, and 11 have an impact on environmental health policy. Goal 3 is to ensure good health and well-being, which affects other goals. If environmental goals are achieved, the health of the country will be able to improve by reducing disease and death. Goal 6 aims to provide clean water and sanitation in countries. Wastewater treatment in countries is an issue that the SDG goals are trying to influence countries to improve and provide better access to clean drinking water and sanitation. Goal 11 of creating sustainable cities and communities is important to environmental health policy since urbanization is a big concern that can affect resources including water, which affects the health of the population.

4.0 CONCLUSION

In this unit, we have been able to define and discuss the links between environment, health and policies. Environmental Health Policy can be implemented at many levels of government, including the community, state and international levels. Furthermore, we were able to look into a few environmental health policies of some developing countries such as Nigeria, India and Kenya as well as policies of some important international organizations like World Health Organization and United Nations.

5.0 SUMMARY

In this unit we have learnt that:

- Environmental health policy refers to the interplay between the environment and health, and how the environment can affect human health
- Environmental Health Policy can be implemented at many levels of government, including the community, state and international levels.
- Community governments focus on policies that affect the boundaries they control.
- State governments focus on several cities or states within their borders where environment affects health.
- International policies involve the cooperation of several states to implement the same policy to address larger environmental issues on health like pollution and climate change.
- Nigeria implemented the World Health Organization Country Cooperation Strategy to deal with Millennium Development Goals in 2014.
- The WHO has also acknowledged that diseases such as diarrhea, respiratory infections, malaria, and unintentional injuries among others can be caused by environmental factors that could be modified by policy.
- Goals 3, 6, and 11 of the United Nations' sustainable development goals have an impact on environmental health policy.

6.0 TUTOR-MARKED ASSIGNMENT

1. Give a concise definition of "policy".
2. Discuss an environmental health policy in Nigeria.
3. Discuss the environmental health policy of the United Nations.

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UNIT 3 ENVIRONMENTAL JUSTICE, LAW AND JURISPRUDENCE

CONTENTS

1.0 INTRODUCTION

Less privileged populations have been known to suffer from harmful effects of activities carried out by more privileged persons, one of which is dumping of toxic wastes near communities. These injustices have led to the coming together of affected communities and concerned individuals and organizations in order to address these injustices and ensure fair treatment of the less privileged communities. These efforts have gone further to ensure that laws are enacted to protect the environment and human populations from harmful activities. One of such is the Harmful waste Act of Nigeria that was enacted in response to the Koko toxic waste dumping incident of 1986. In this unit, we will look at the origins of environmental justice, its definition and some important environmental laws and legislations in Nigeria.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- trace the origins of environmental justice
- explain environmental justice
- discuss the environmental laws of Nigeria.

3.0 MAIN CONTENT

3.1 Origin and Definition of Environmental Justice

The modern environmental justice movement dates from around 1980. In 1979, the African American community of North Hollywood, in Houston, Texas, filed suit to prevent the building of a solid waste landfill in *Bean* v. *Southwestern Waste Management.* In 1982, the predominantly African American community in Warren County, North Carolina, protested the siting of a Polycyclic Bisphenols landfill. This incident brought together the environmental and civil rights communities and attracted national attention. It gave rise to the landmark 1987 United Church of Christ (UCC) study *Toxic Wastes and Race in the United States*, the first national study of the demographic patterns associated with the location of hazardous waste sites (UCC, 1987; Lee, 1993).

These events gave impetus to the emerging consciousness about environmental conditions in low-income and tribal communities and communities of people of color. A groundswell of activity began to take place in these communities around a vast array of issues, including but not limited to toxicants, lead poisoning, housing, land use, air quality, workplace health and safety, transportation, and economic development.

As the environmental justice paradigm matured, it became more holistic, increasingly viewing individual and community health as a product of physical, social, cultural, and spiritual factors. Environmental justice represents a vision born out of a community-driven process whose essential core is a transformative public discourse over what constitutes truly healthy, livable, sustainable, and vital communities for all peoples.

It has given birth to a broad definition of the environment as “the place where we live, where we work, and where we play”. It sees the ecosystem that forms the basis for life and well-being as composed of four interrelated environments: natural, built, social, and cultural and spiritual. It has made clear the necessity for public participation and accountability in formulating environmental policy. It has expanded environmental health discourse to include issues of multiple, cumulative, and synergistic risks. It has pressed for a new paradigm that features community-driven science and holistic, placed-based, systems-wide environmental protection.

3.2 Environmental Laws and Legislation in Nigeria

The role legislation plays in ensuring responsible attitudes and behaviours towards the environment is important. Legislation serves as an effective tool for environmental protection, planning, pollution prevention and control. Nigerian legislation on the environment are below;

3.2.1 Constitution Of The Federal Republic Of Nigeria (1999)

The constitution, as the national legal order, recognizes the importance of improving and protecting the environment and makes provision for it. Relevant sections are:

- **Section 20**: the Nigerian State should improve and protect the air, land, water, forest and wildlife of Nigeria.
- **Section 12**: International treaties (including environmental treaties) ratified by the National Assembly should be implemented as law in Nigeria.
- **Section 33 and 34:** guarantees fundamental human rights to life and human dignity respectively and have being argued to be linked to the need for a healthy and safe environment to give these rights effect.

3.2.2 National Environmental Standards And Regulation Enforcement Agency (NESREA) Act 2007

The National Environment Standards and Regulation Enforcement Agency (NESREA) Act of 2007 replaced the Federal Environmental Protection Agency (FEPA) Act. It is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources. The following sections are important;

- **Section 7:** Ensure compliance with environmental laws, local and international, on environmental sanitation and pollution prevention and control through monitory and regulatory measures.
- **Section 8 (1)(K): M**ake and review regulations on air and water quality, effluent limitations, control of harmful substances and other forms of environmental pollution and sanitation.
- **Section 27:** prohibits, without lawful authority, the discharge of hazardous substances into the environment. This offence is punishable under this section, with a fine not exceeding, N1,000,000 (One Million Naira) and an imprisonment term of 5 years. In the case of a company, there is an additional fine of N50,000, for every day the offence persists.

National Effluent Limitation Regulations

- **Section 1 (1):** Industries must have anti-pollution facilities and equipment for the treatment of effluents.
- **Section 3 (2):** Compositions of the industry's treated effluents must be submitted to NESREA.

National Environment Protection (Pollution Abatement in Industries and Facilities producing Waste) Regulations (1991).

- **Section 1:** Prohibition of the release of hazardous substances into the air, land or water of Nigeria beyond approved limits set by NESREA.
- **Section 4 and 5:** Industries are to report a discharge if it occurs and to submit a comprehensive list of chemicals used for production to NESREA.

Federal Solid and Hazardous Waste Management Regulations (1991).

- **Section 1:** Industries are to identify solid hazardous wastes which are dangerous to public health and the environment and to research into the possibility of their recycling.
- **Section 20: NESREA must be n**otified of any discharge.
- **Section 108:** stipulates penalties for contravening any regulation.

4.0 CONCLUSION

In this unit, we have been able to look into the origins of environmental justice as arising from a period in which people were subjected to unfavourable environmental conditions because of their less privileged status and the colour of their skin. Environmental justice was birthed to address these inequalities and unpleasant situations. We further looked into some important environmental laws and regulations in Nigeria and the role being played by NESREA in environmental protection.

5.0 SUMMARY

In this unit we have learnt that:

- The modern environmental justice movement dates from around 1980.
- Environmental justice represents a vision born out of a community-driven process whose essential core is a transformative public discourse over what constitutes truly

healthy, livable, sustainable, and vital communities for all peoples.

- The role legislation plays in ensuring responsible attitudes and behaviours towards the environment is important.
- The constitution, as the national legal order, recognizes the importance of improving and protecting the environment and makes provision for it.
- The NESREA Act is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources.
- The EIA Act is an important part of public and private projects and it examines the impacts of such projects on the natural environment.
- The Harmful Waste Act prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria.

6.0 TUTOR-MARKED ASSIGNMENT

1. Give a concise definition of environmental justice.
2. List three environmental legislations in Nigeria.
3. Explain the Environmental Impact Assessment (EIA) Act.

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UNIT 4 ENVIRONMENTAL GOVERNANCE

CONTENTS

1.0 INTRODUCTION

Environmental governance is a concept in politics and environmental policy that advocates sustainable development as the supreme consideration for managing all human activities (political, social and economic). Governance includes government, business and civil society and emphasizes whole system management. In this unit, we will consider how environmental issues are tackled by political structures and current institutions providing environmental governance globally.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain environmental governance
- explain the different levels of environmental governance
- discuss environmental governance issues
- identify environmental conventions and governing institutions.

3.0 MAIN CONTENT

3.1 What is Environmental Governance?

Environmental governance refers to the processes of decision-making involved in the control and management of the environment and natural resources. Environmental Governance is defined as the 'Multi-level

interactions (i.e., local, national, international/global) among, but not limited to, three main actors, i.e., state, market, and civil society, which interact with one another, whether in formal and informal ways; in formulating and implementing policies in response to environment-related demands and inputs from the society; bound by rules, procedures, processes, and widely accepted behavior; possessing characteristics of good governance; for the purpose of attaining environmentally-sustainable development' (ICUN 2010).
Key principles of environmental governance include:

- Embedding the environment in all levels of decision-making and action
- Conceptualizing cities and communities, economic and political life as a subset of the environment
- Emphasizing the connection of people to the ecosystems in which they live
- Promoting the transition from cradle-to-grave systems (like garbage disposal with no recycling) to cradle-to-cradle systems (like zero waste strategies).

Global, continental, national and local governments have employed a variety of approaches to environmental governance. However, there are challenges facing environmental governance. Some of which include;

- Inadequate continental and global agreements
- Unresolved tensions between maximum development, sustainable development and maximum protection, limiting funding, damaging links with the economy and limiting application of Multilateral Environment Agreements (MEAs).
- Environmental funding is not self-sustaining, diverting resources from problem-solving into funding battles.
- Lack of integration of sector policies
- Inadequate institutional capacities
- Ill-defined priorities
- Unclear objectives
- Lack of coordination within the UN, governments, the private sector and civil society
- Lack of shared vision
- Interdependencies among development/sustainable economic growth, trade, agriculture, health, peace and security.
- International imbalance between environmental governance and trade and finance programs, e.g., World Trade Organization (WTO).
- Limited credit for organizations running projects within the Global Environment Facility (GEF)

- Linking UNEP, United Nations Development Programme (UNDP) and the World Bank with MEAs
- Lack of government capacity to satisfy MEA obligations
- Absence of the gender perspective and equity in environmental governance
- Inability to influence public opinion

3.2 Levels of Environmental Governance

There are three levels of environmental governance:

3.2.1 Local governance

Community participation and partnership along with the decentralization of government power to local communities are important aspects of environmental governance at the local level. Initiatives such as these are integral divergence from previous environmental governance approaches which was driven by state agendas and resource control and followed a top-down approach rather than the bottom up approach that local level governance encompasses. Local level governance shifts decision making power away from the state and/or governments to the grassroots. Local level governance is extremely important even on a global scale. Environmental governance at the global level is defined as international and as such has resulted in the marginalization of local voices.

Local level governance is important to bring back power to local communities in the global fight against environmental degradation. Issues raised on biodiversity can be faced by adopting appropriate policies and strategies through exchange of knowledge and experience, the forming of partnerships, correct management of land use, monitoring of biodiversity and optimal use of resources, or reducing consumption, and promoting environmental certifications. Local authorities undoubtedly have a central role to play in the protection of biodiversity and this strategy is successful above all when the authorities show strength by involving stakeholders in a credible environmental improvement project and activating a transparent and effective communication policy.

3.2.2 State governance

States play a crucial role in environmental governance, because however far and fast international economic integration proceeds, political authority remains vested in national governments. At the state level, environmental management has been found to be conducive to the creation of committees especially in developed countries. In developing countries, the main obstacle to the integration of intermediate levels in the process of territorial environmental governance development is often the idea that environmental protection curbs economic and social development, an idea encouraged by the passion for exporting raw materials extracted using destructive methods that consume resources and fail to generate any added value. They may however be justified in this thinking, as their main concerns are social injustices such as poverty alleviation. Citizens in some of these states have responded by developing empowerment strategies to ease poverty through sustainable development.

3.2.3 Global Governance

At the global level there are numerous important stakeholders involved in environmental governance and a range of institutions contribute to and help define the practice of global environmental governance. The idea of global environmental governance is to govern the environment at a global level through a range of nation states and non-state actors such as national governments, NGOs and other international organizations such as UNEP (United Nations Environment Programme). Global environmental governance is the answer to calls for new forms of governance because of the increasing complexity of the international agenda. It is perceived to be an effective form of multilateral management and essential to the international community in meeting goals of mitigation and the possible reversal of the impacts on the global environment. However, a precise definition of global environmental governance is still vague and there are many issues surrounding global governance.

3.3 Environmental Governance Issues

Some issues being tackled in environmental governance include;

Soil deterioration

Soil and land deterioration reduces its capacity for capturing, storing and recycling water, energy and food. An international organization known as Alliance 21 proposed solutions in the following areas; include soil rehabilitation as part of conventional and popular education, involve all stakeholders, including policymakers and authorities, producers and land users, the scientific community and civil society to manage incentives and enforce regulations and laws, establish a set of binding rules, such as an international convention, set up mechanisms and incentives to facilitate transformations, gather and share knowledge and mobilize funds nationally and internationally.

Climate change

The scientific consensus on climate change is expressed in the reports of Intergovernmental Panel on Climate Change (IPCC) and also in the statements by all major scientific bodies in the United States such as National Academy of Sciences. There has been increasing actions in order to mitigate climate change and reduce its impact at national, regional and international levels. Kyoto protocol and United Nations Framework Convention on Climate Change (UNFCCC) plays the most important role in addressing climate change at an international level. The goal of combating climate change led to the adoption of the Kyoto Protocol by 191 states, an agreement encouraging the reduction of greenhouse gases, mainly CO_2.

Biodiversity conservation

The Convention on Biological Diversity (CBD) was signed in Rio de Janeiro in 1992 human activities. The CBD's objectives are: "to conserve biological diversity, to use biological diversity in a sustainable fashion, to share the benefits of biological diversity fairly and equitably." The Convention is the first global agreement to address all aspects of biodiversity: genetic resources, species and ecosystems. It recognizes, for the first time, that the conservation of biological diversity is "a common concern for all humanity". The Convention encourages joint efforts on measures for scientific and technological cooperation, access to genetic resources and the transfer of clean environmental technologies.

Ozone layer depletion

The United Nations General Assembly signed the Montreal Protocol to address the declining ozone layer on 16 September 1987. Since that time, the use of chlorofluorocarbons (industrial refrigerants and aerosols) and farming fungicides such as methyl bromide has mostly been eliminated, although other damaging gases are still in use.

3.4 Conventions and International Institutions

Some multilateral conventions, are as follows:

1. Convention on Biological Diversity (CBD) (1992–1993)
2. United Nations Framework Convention on Climate Change (UNFCC) (1992–1994
3. United Nations Convention to Combat Desertification (UNCCD) (1994–1996
4. UNESCO World Heritage Convention (1972–1975)

5. Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) (1973–1975)
6. Bonn Convention on the Conservation of Migratory Species (1979–1983)
7. Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (1992–1996)
8. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989–1992)
9. Rotterdam Convention on the Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade
10. Stockholm Convention on Persistent Organic Pollutants (COP) (2001–2004)

Some important international institutions in environmental governance include;

United Nations Environment Program (UNEP)

The UNEP has had its biggest impact as a monitoring and advisory body, and in developing environmental agreements. It has also contributed to strengthening the institutional capacity of environment ministries.

United Nations Commission on Sustainable Development (CSD)
This intergovernmental institution meets twice a year to assess follow-up on Rio Summit goals. The CSD is made up of 53 member states, elected every three years and was reformed in 2004. It meets twice a year, focusing on a specific theme during each two-year period.

World Bank

The World Bank influences environmental governance through other actors, particularly the Global Environment Facility. The World Bank's mandate is not sufficiently defined in terms of environmental governance despite the fact that it is included in its mission. However, it allocates 5 to 10% of its annual funds to environmental projects.

Global Environment Facility (GEF)

The GEF's reputes itself as the largest public funder of projects to improve the global environment. It provides grants for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer and persistent organic pollutants. It serves as mechanism for the; Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC), Stockholm Convention on Persistent Organic Pollutants (POPs), Convention to Combat Desertification (UNCCD) and implementation of Montreal Protocol on Substances That Deplete the Ozone Layer in some countries with economies in transition.

United Nations International Council for Local Environmental Initiatives (UN ICLEI)

The UN's main body for coordinating municipal and urban decision-making is named the International Council for Local Environmental Initiatives. Its slogan is "Local Governments for Sustainability". This body sponsored the concept of full cost accounting that makes environmental governance the foundation of other governance.

4.0 CONCLUSION

In this unit, we have learnt that environmental governance refers to the processes of decision-making involved in the control and management of the environment and natural resources. We also learnt that there are three levels of environmental governance; local, state and global. Some common environmental governance issues include; biodiversity conservation, climate change soil degradation among others. Important conventions include; Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC), Stockholm Convention on Persistent Organic Pollutants (POPs) etc. International institutions such as the United Nations Environment Programme, Global Environment Facility among others have been providing leadership in tackling environmental issues globally.

5.0 SUMMARY

In this unit we have learnt that:

- Environmental Governance is defined as the 'Multi-level interactions (i.e., local, national, international/global) among, but not limited to, three main actors, i.e., state, market, and civil society, which interact with one another, whether in formal and informal ways; in formulating and implementing policies in response to environment-related demands and inputs from the society; bound by rules, procedures, processes, and widely accepted behavior; possessing characteristics of good governance; for the purpose of attaining environmentally-sustainable development'

- Local level governance shifts decision making power away from the state and/or governments to the grassroots.
- States play a crucial role in environmental governance, because however far and fast international economic integration proceeds, political authority remains vested in national governments.
- The idea of global environmental governance is to govern the environment at a global level through a range of nation states and non-state actors such as national governments, NGOs and other international organizations such as UNEP (United Nations Environment Programme).
- Some issues being tackled in environmental governance include; soil degradation, biodiversity, climate change and ozone layer depletion.
- Some multilateral conventions, include; Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC), Stockholm Convention on Persistent Organic Pollutants (POPs), Convention to Combat Desertification (UNCCD).
- Some important international institutions in environmental governance include; United Nations Environmental Programme, United Nations Commission on Sustainable Development, World Bank and Global Environment Facility among others.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define environmental governance.
2. Mention three environmental issues.
3. List five environmental conventions.
4. List three international environmental governance institutions.

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MODULE 6 CURRENT ISSUES IN ENVIRONMENTAL HEALTH

UNIT 1 CLIMATE CHANGE

CONTENTS

1.0 INTRODUCTION

Climate change has been the top agenda and front burner among global issues in recent times. You might think it's a hoax but take some time to reflect and study the unusual weather patterns, frequent international disasters such as flooding, hurricanes, cyclones, etc. and increase in diseases especially in tropical regions. These are some of the evidences for climate change on our planet. By the end of this unit, you will probably become fully aware of what climate change is and how it impacts the environment and human health.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain how climate change occurs
- discuss the consequences and impacts of climate change on human health

3.0 MAIN CONTENT

3.1 What is Climate Change?

Climate change is a change in the distribution of weather patterns when that change lasts for an extended period of time. Climate change may refer to a change in average weather conditions or in the time variation of weather within the context of longer-term average conditions. Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain anthropogenic activities have been identified as primary sources of ongoing climate change, often referred to as global warming. Of most concern in these anthropogenic factors is the increase in CO_2 levels. This is due to emissions from fossil fuel combustion and aerosols (particulate matter in the atmosphere). Other factors, including land use, ozone layer depletion, animal husbandry and deforestation, are also of concern in the roles they play.

Climate change, whether due to natural variability or resulting from human activity, depends on the balance between incoming (solar) shortwave radiation and outgoing longwave radiation. This balance is affected by the earth's atmosphere, in much the same way that a glass greenhouse (or a car's windshield on a hot day) allows sunlight energy to penetrate through the glass and traps heat (infrared) energy inside. An atmosphere that retains more heat, because it has higher levels of so called greenhouse gases, will result in higher average surface temperatures than will an atmosphere with lower levels of these gases.

Higher greenhouse gas concentrations have contributed to warming of the earth by absorbing and reemitting infrared radiation toward the lower atmosphere and Earth's surface. Warmer air holds more moisture, resulting in more precipitation in some areas. Wind patterns change. Arctic and Antarctic ice melts, releasing vast amounts of water into the oceans, raising ocean levels and potentially altering the flows of ocean currents. The weather patterns that result from these and other changes vary greatly from place to place. Although many places become warmer, others become colder. Although some become wetter, others become drier.

3.2 Climate Change and Health

Weather Extremes and Health: Results of climate change such as extreme temperatures, severe storms, rising sea levels and droughts all put the health of the earth's populations at serious risk.

Thermal Stress: Extremes of both hot and cold temperatures are associated with rates of morbidity and mortality higher than the rates in the intermediate or comfortable, temperature range. The body's thermoregulatory mechanisms can cope with a certain amount of temperature rise through control of perspiration and vasodilation of cutaneous vessels. The ability to respond to heat stress is thus limited by the capacity to increase cardiac output as required for greater cutaneous blood flow.

Severe Storms and Sea-level Rise: Floods, droughts and extreme storms have claimed millions of lives in recent times and have adversely affected the lives of many more millions of people and caused billions of dollars in property damage. Mental disorders such as posttraumatic stress disorder (PTSD) may substantially affect population well-being, depending on the unexpectedness of the impact, the intensity of the experience, the degree of personal and community disruption, and long-term exposure to the visual signs of the disaster. Degradation of the local environment can also contribute significantly to vulnerability. Hurricanes form only in regions where sea surface temperatures are above 26°C. In addition, sea surface warming will necessarily cause a rise in sea level. One expected effect will be an increase in flooding and coastal erosion in low-lying coastal areas.

Drought: Drought is also projected to be an increasing problem with climate change. Food production depends on weather conditions despite technological advances such as improved crop varieties and irrigation systems. Diarrhea and diseases such as scabies, conjunctivitis, and trachoma are associated with poor hygiene and can result from a breakdown in sanitation when water resources become depleted. Drought can also induce wildfires that threaten health both directly and through poor air quality.

Weather, Air Pollution, and Health: Climate change may affect exposure to air pollutants in many ways because it can influence both the levels of pollutants that are formed and the ways these pollutants are dispersed. If the climate becomes warmer and more variable, air quality is likely to suffer. Ozone is an example of a pollutant whose concentration may increase with a warmer climate. Another air contaminant that may increase with climate change is pollen. Higher levels of carbon dioxide promote growth and reproduction by many plants, including those that produce allergens. Once pollutants are formed, climate change may affect how much people are exposed. Weather influences the dispersal and ambient concentrations of many pollutants. For example, increased wind accompanying warmer air may distribute pollutants over broad areas.

Waterborne Diseases: Waterborne diseases are likely to become a greater problem as climate change continues and affects both freshwater and marine ecosystems. In freshwater systems, both water quantity and water quality can be affected by climate change. In marine waters, changes in temperature and salinity will affect coastal ecosystems in ways that may increase the risk of certain diseases. Waterborne diseases are particularly sensitive to changes in the hydrologic cycle. Water shortages contribute to poor hygiene and that in turn contributes to diarrheal disease, especially in poor countries. At the other extreme, flooding can contaminate drinking water with runoff from sewage lines, containment lagoons. Heavy runoff after severe rainfall can also contaminate recreational waters and increase the risk of human illness.

Vector-Borne Diseases: The life cycle of vector-borne pathogens (for example, protozoa, bacteria, and viruses) involves much time outside the human host and therefore much exposure to and influence from environmental conditions. The range of climatic conditions in which each infective or vector species can survive and reproduce is limited. The incubation time of a vector-borne infective agent within its vector organism is typically very sensitive to changes in temperature and humidity.

Mosquito-Borne Diseases: Malaria is transmitted to humans by mosquitoes. Because insects are cold-blooded, climate change can shift the distribution of mosquito populations, affect mosquito biting rates and survival, and shorten or lengthen pathogen development time inside the mosquito, which ultimately determines infectivity. Malaria is a temperature-sensitive disease. According to the World Health Organization (1996), malaria is the vector-borne disease most sensitive to long-term climate change. The incidence of malaria varies seasonally in highly endemic areas, and malaria transmission has been associated with temperature anomalies in some African highland areas.

Food Productivity and Malnutrition: Climate change is likely to have major effects on crop and livestock production. Some changes will be positive and others negative, and the net impact on food production will likely vary from place to place. Changes in food production will depend on several key factors. First are the direct effects of temperature, precipitation, CO_2 levels and extreme climate variability and sea-level rise. Next are the indirect effects of climate-induced changes in soil quality, incidence of plant diseases, and weed and insect populations. Greater heat and humidity will also increase food spoilage.

4.0 CONCLUSION

In this unit, it has been explained that climate change is a change in weather distribution patterns over an extended period of time. It has also been established that climate change can be linked to natural and anthropogenic activities and it also hinges on disruptions in the balance between incoming shortwave radiation and outgoing longwave radiation. Greenhouse gases are the greatest contributors to climate change as they trap and reemit infrared rays towards the earth surface, thus creating a warmer atmosphere with its consequent impact on weather and human health. Some of these effects include weather extremes, thermal stress, severe storms and sea-level rise, drought, air pollution, waterborne disease and vector-borne diseases among others.

5.0 SUMMARY

In this unit, we have learnt that:

- Climate change is a change in the distribution of weather patterns when that change lasts for an extended period of time.
- Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions.
- Certain anthropogenic activities have been identified as primary sources of ongoing climate change, often referred to as global warming. Of most concern in these anthropogenic factors is the increase in CO_2 levels. This is due to emissions from fossil fuel combustion and aerosols (particulate matter in the atmosphere).
- Climate change, whether due to natural variability or resulting from human activity, depends on the balance between incoming (solar) shortwave radiation and outgoing longwave radiation.
- Results of climate change such as extreme temperatures, severe storms, rising sea levels and droughts all put the health of the earth's populations at serious risk.
- Extremes of both hot and cold temperatures are associated with rates of morbidity and mortality higher than the rates in the intermediate or comfortable, temperature range.
- Drought is also projected to be an increasing problem with climate change. Diarrhea and diseases such as scabies, conjunctivitis, and trachoma are associated with poor hygiene and can result from a breakdown in sanitation when water resources become depleted.
- Climate change may affect exposure to air pollutants in many ways because it can influence both the levels of pollutants that are formed and the ways these pollutants are dispersed.

- Waterborne diseases are particularly sensitive to changes in the hydrologic cycle. Water shortages contribute to poor hygiene and that in turn contributes to diarrheal disease, especially in poor countries. At the other extreme, flooding can contaminate drinking water with runoff from sewage lines, containment lagoons. Heavy runoff after severe rainfall can also contaminate recreational waters and increase the risk of human illness.
- The range of climatic conditions in which each infective or vector species can survive and reproduce is limited. The incubation time of a vector-borne infective agent within its vector organism is typically very sensitive to changes in temperature and humidity.
- Malaria is the vector-borne disease most sensitive to long-term climate change.
- Climate change is likely to have major effects on crop and livestock production.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define Climate Change.
2. List five impacts of climate change on human health.

7.0 REFERENCES/FURTHER READING

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UNIT 2 BIOTERRORISM

CONTENTS

1.0 INTRODUCTION

Although not popular among developing or under-developing countries, bioterrorism is of greater concern among world powers and if not tackled effectively can adversely affect human health and the environment. In an era of terrorism, global insecurity and easy movements across borders as well as increased technological advancement, bio-agents can easily be developed, modified and disseminated thus wrecking much havoc. By the end of this unit, you will have been sensitized and gained knowledge on potential bio-agents, their impacts on human health as well as preparedness and response strategies.

2.0 OBJECTIVES

By the end of this Unit, you will be able to:

- discuss the various types and categories of bio-agents
- explain possible impacts of bioterrorism
- discuss the planning, response and preparedness towards bioterrorism attacks.

3.0 MAIN CONTENT

3.1 What is bioterrorism?

Bioterrorism is terrorism involving the intentional release or dissemination of biological agents. These agents are bacteria, viruses, fungi or toxins and may be in a naturally occurring or a human-modified form. According to the U.S. Centers for Disease Control and Prevention, bioterrorism is the deliberate release of viruses, bacteria, toxins or other harmful agents to cause illness or death in people, animals, or plants. These agents are typically found in nature, but could be mutated or altered to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment. Biological agents can be spread through the air, water, or in food. Terrorists tend to use biological agents because they are extremely difficult to detect and do not cause illness for several hours to several days. Some bioterrorism agents, like the smallpox virus, can be spread from person to person and some, like anthrax, cannot.

Bioterrorism is an attractive weapon because biological agents are relatively easy and inexpensive to obtain, can be easily disseminated, and can cause widespread fear and panic beyond the actual physical damage. A biological weapon is useful to terrorists mainly as a method of creating mass panic and disruption to a state or a country. The use of agents that do not cause harm to humans but disrupt the economy have been discussed. A highly relevant pathogen in this context is the foot-and-mouth disease (FMD) virus, which is capable of causing widespread economic damage and public concern as witnessed in the 2001 and 2007 FMD outbreaks in the UK), whilst having almost no capacity to infect humans.

3.2 Types of agents

Bio-agents that can potentially cause harm to humans are categorized into A, B or C agents.

Category A

These high-priority agents pose a risk to national security, can be easily transmitted and disseminated, result in high mortality, have potential major public health impact, may cause public panic, or require special action for public health preparedness. *Bacillus anthracis* (anthrax) and *Clostridium botulinum* (botulism) have been rated as high-priority biological agents (Category A), because they are easy to disseminate and cause severe morbidity and moderate to high mortality.

Category B

Category B agents are moderately easy to disseminate and have low mortality rates. Most of the foodborne biological agents identified have been classified as Category B agents. because they are moderately easy to disseminate and cause moderate morbidity and low mortality. The Category B biological agents include *Salmonella* spp., *Shigelladysenteriae*, *E. coli* O157:H7, and ricin.

Category C

Category C agents are emerging pathogens that might be engineered for mass dissemination because of their availability, ease of production and dissemination, high mortality rate, or ability to cause a major health impact.

3.3 Planning, Response and Preparedness

Biological agents are relatively easy to obtain by terrorists and in developed countries, laboratories are working on advanced detection systems to provide early warning, identify contaminated areas and populations at risk and to facilitate prompt treatment. Methods for predicting the use of biological agents in urban areas as well as assessing the area for the hazards associated with a biological attack are being established in major cities of developed countries. In addition, forensic technologies are working on identifying biological agents, their geographical origins and/or their initial source. Efforts include decontamination technologies to restore facilities without causing additional environmental concerns.

In countries like the United States, some of the aspects of protection against bioterrorism include;

Detection and resilience strategies in combating bioterrorism: There is a BioWatch program in which collection devices are disseminated to thirty high risk areas throughout the country to detect the presence of aerosolized biological agents before symptoms present in patients. This is significant primarily because it allows a more proactive response to a disease outbreak rather than the more passive treatment of the past.

Implementation of the Generation-3 automated detection system: This advancement is significant simply because it enables action to be taken in four to six hours due to its automatic response system, whereas the previous system required aerosol detectors to be manually transported to laboratories.

Enhancing the technological capabilities of first responders: is accomplished through numerous strategies. The first of these strategies was developed by the Science and Technology Directorate (S&T) of DHS to ensure that the danger of suspicious powders could be effectively assessed, (as many dangerous biological agents such as anthrax exist as a white powder). By testing the accuracy and specificity of commercially available systems used by first responders, the hope is that all biologically harmful powders can be rendered ineffective.

Enhanced equipment for first responders: One recent advancement is the commercialization of a new form of body armor which protects first responders and patients from chemical and biological contaminants. There has also been a new generation of Self-Contained Breathing Apparatuses (SCBA) which has been recently made more robust against bioterrorism agents. All of these technologies combine to form what seems like a relatively strong deterrent to bioterrorism.

Furthermore, certain chemicals as possible agents for a terrorist attack. These include heavy metals, such as arsenic, lead, and mercury, and pesticides, dioxins, furans, and Polycyclic Bisphenols (PCBs), all of which can be used to contaminate food. These toxins too have been introduced inadvertently into foods at times and linked to human health effects.

4.0 CONCLUSION

In this unit, we have been able to look at bioterrorism as an intentional act of disseminating biological agents or harmful substances in order to cause illnesses or death. These agents are naturally occurring but can also be modified for more harmful and potent effect as well as to aid wider coverage. Bio-agents can be classified into A,B and C categories and developed countries such as the United States have developed strategies for planning, response and preparedness towards bioterrorism attacks.

5.0 SUMMARY

In this unit we have learnt that;

- Bioterrorism is terrorism involving the intentional release or dissemination of biological agents.
- These agents are typically found in nature, but could be mutated or altered to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment.
- Biological agents can be spread through the air, water, or in food.
- Bio-agents that can potentially cause harm to humans are categorized into A, B or C agents.
- Biological agents are relatively easy to obtain by terrorists and in developed countries, laboratories are working on advanced detection systems to provide early warning, identify contaminated areas and populations at risk and to facilitate prompt treatment.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is bioterrorism?
2. List the three categories of bio-agents.
3. Mention two examples each of bio-agents in categories A and B.
4. List five chemicals that have also been identified as possible agents for terrorist attacks.

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