COURSE GUIDE

SLM 504
ANTHROPOGENIC IMPACT ON LAND

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Published by
National Open University of Nigeria

Printed 2016

ISBN: 978-058-510-2

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INTRODUCTION

SLM 504: Anthropogenic impact on land is a two-credit course for undergraduate students of Agriculture in the School of Agricultural Science.

The course consists of eight modules which is divided into26 units. The material has been developed to suit the needs of students of Agriculture at the National Open University of Nigeria (NOUN) by using an approach that treats anthropogenic impact on land.

A student who successfully completes the course will surely be in a better position to manage impact on land in both private and public organisations.

The Course Guide tells you briefly what the course is about, what course materials you will be using and how you can work your way through these materials. It suggests some general guidelines for the amount of time you are likely to spend on each unit of the course in order to complete it successfully. It also gives you some guidance on your tutor-marked assignment. Detailed information on tutor-marked assignment is found in the separate assignment file which will be available in due course.

WHAT YOU WILL LEARN IN THIS COURSE

In this course, you will be introduced to some fundamental aspects of farm and farming systems, classification of farming systems, husbandry, land use in the tropics, matching land uses to land types, soil erosion, processes of soil erosion, economic importance of soil erosion, types of soil erosion, soil productivity relation and modeling, meaning of soil conservation, agronomic practices for soil conservation measures, soil management strategies for soil conservation, mechanical strategies for soil conservation and extension approaches for soil conservation

COURSE AIM

The aim of this course is to equip you with relevant knowledge about farming systems and soil management strategies that will prevent or minimise soil erosion. It is this knowledge and its application that will guarantee adequate productivity of the soil.

COURSE OBJECTIVES

- To achieve this aim, it is expected that at the end of this course, you should be able to:
- explain the concept of a farming system and list the components of a farming system
- state general classification of farming system in a pictorial or diagrammatic form
- list and briefly explain two main classes of farming system
- classify farming system according to cultivation with example in each classification
- explain the concept of land husbandry and state the characteristics of land husbandry
- list and briefly explain the principles of land husbandry
- define land use with examples and list the functions of land use
- explain land capability classification and give examples of land use matching land type
- define soil erosion and outline causative agent of soil erosion
- explain the three processes of soil erosion, outline factors of water erosion and
- factor affecting water erosion
- explain major soil properties controlling soil erosion at field-scale, on-site and
- off-site problems of erosion
- list and discuss briefly different kinds and types of erosion
- outline the relationship between soil erosion and agricultural productivity
- explain the erosion modeling, differentiate between empirical and conceptual models
- and the universal soil loss equation
- explain soil conservation and control measures
- list and highlight the various extension approaches of soil conservation.

WORKING THROUGH THE COURSE

To successfully complete this course, you are required to read the study units, reference books and other materials on the course.

Each unit contains self-assessment exercises in addition to tutor-marked assignments (TMAs). At some points in the course, you will be required to submit assignments for assessment purposes. At the end of the course there is a final examination. This course should take about 15 weeks to complete and some components of the course are outlined under the course material subsection.

COURSE MATERIALS

The major components of the course are:

Course Guide
Study Units
Textbooks
Assignment File
Presentation schedule.

STUDY UNITS

There are three modules of 26 units in this course:

Module 1	**Current Types of Soil Resources Concepts**
Unit 1	Users Concept of Definition of Soil as a Resource
Unit 2	Composition of Soils
Unit 3	Soil Properties
Unit 4	Soil Classification Systems
Unit 5	Earth Natural Resources
Module 2	**Land Use as Related To Soils**
Unit 1	Meaning of Soil and Land
Unit 2	Uses of Land
Unit 3	Land Use and Land Cover Change
Module 3	**Interaction Technology on Soil Environment**
Unit1	Concept of Interactive Technology
Unit 2	Forms of Organic and Inorganic Materials Interaction
Unit 3	Interaction of Microorganisms
Module 4	**Effect of Fertilisers on the Soil-Water Ecosystem**
Unit 1	Component and Importance of Mineral Fertilisers
Unit 2	Effect of Fertiliser on Soil Properties and Soil Organisms
Unit 3	Effect of Fertiliser on Water and Atmospheric Environment
Unit 4	Long and Short Term Effect of Fertilisers
Module 5	**Effect of Pesticides and Herbicides on the Soil-Water Ecosystem**
Unit 1	Fate of Pesticides
Unit 2	Effect of Pesticides on Soils and Water Ecosystems
Unit 3	Effect of Pesticides on Organisms
Unit 4	Effect of Herbicides on Soil

REFERENCES/FURTHER READING

Every unit contains a list of references and further reading. Try to get as many as possible of those textbooks and materials listed. The textbooks and materials are meant to deepen your knowledge of the course.

ASSIGNMENT FILE

There are many assignments in this course and you are expected to do all of them. You should follow the schedule prescribed for them in terms of when to attempt the homework and submit same for grading by your tutor.

PRESENTATION SCHEDULE

The presentation schedule included in your course materials gives you the important dates for the completion of tutor-marked assignments and attending tutorials. Remember, you are required to submit all your assignments by the due date. You should guard against falling behind in your work.

ASSESSMENT

Your assessment will be based on tutor-marked assignments (TMAs) and a final examination which you will write at the end of the course.

TUTOR-MARKED ASSIGNMENT

Assignment questions for the 15 units in this course are contained in the assignment file. You will be able to complete your assignments from the information and materials contained in your set books, reading and study units. However, it is desirable that you demonstrate that you have read and researched more widely than the required minimum. You should use other references to have a broad viewpoint of the subject and also to give you a deeper understanding of the subject.

When you have completed each assignment, send it, together with a TMA form, to your tutor. Make sure that each assignment reaches your tutor on or before the deadline given in the presentation file. If for any reason, you cannot complete your work on time, contact your tutor before the assignment is due to discuss the possibility of an extension. Extensions will not be granted after the due date unless there are exceptional circumstances. The TMAs usually constitute 30% of the total score for the course.

FINAL EXAMINATION AND GRADING

The final examination will be of two-hour duration and have a value of 70% of the total course grade. The examination will consist of questions which reflect the types of self-assessment practice exercises and tutor-Marked problems you have previously encountered. All areas of the course will be assessed.
You should use the time between finishing the last unit and sitting for the examination to revise the entire course material. You might find it useful to review your self-assessment exercises, tutor-marked assignments and comments on them before the examination. The final examination covers information from all parts of the course.

COURSE MARKING SCHEME

The table below indicates the total marks (100%) allocation.

Assignment (best three assignments out of the four Marked)	30%
Final Examination	70%
Total	100%

HOW TO GET THE MOST FROM THIS COURSE

In distance learning, the study units replace the university lecturer. This is one of the great advantages of distance learning; you can read and work through specially designed study materials at your own pace and at a time and place that suit you best. Think of it as reading the lecture

notes instead of listening to a lecturer. In the same way that a lecturer might set you some reading to do, the study units tell you when to read your books or other material, and when to embark on discussion with your colleagues. Just as a lecturer might give you an in-class exercise, your study units provides exercises for you to do at appropriate points.
Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next is a set of learning objectives. These objectives let you know what you should be able to do by the time you have completed the unit. You should use these objectives to guide your study. When you have finished the unit you must go back and check whether you have achieved the objectives. If you make a habit of doing this you will significantly improve your chances of passing the course and getting the best grade.

The main body of the unit guides you through the required reading from other sources. This will usually be either from your set books or from a readings section. Self-assessments are interspersed throughout the units, and answers are given at the ends of the units. Working through these tests will help you to achieve the objectives of the unit and prepare you for the assignments and the examination. You should do each self-assessment exercise as you come to it in the study unit. Also, ensure to master some major historical dates and events during the course of studying the material.

The following is a practical strategy for working through the course. If you run into any trouble, consult your tutor. Remember that your tutor's job is to help you. When you need help, don't hesitate to call and ask your tutor to provide the help.

Read this Course Guide thoroughly

Organise a study schedule. Refer to the `Course overview' for more details. Note the time you are expected to spend on each unit and how the assignments relate to the units. Important information, e.g. details of your tutorials, and the date of the first day of the semester is available from study centre. You need to gather together all this information in one place, such as your dairy, a wall calendar, an iPad or a handset. Whatever method you choose to use, you should decide on and write in your own dates for working each unit.

Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is that they get behind with their course work. If you get into difficulties with your schedule, please let your tutor know before it is too late.
Turn to Unit 1 and read the introduction and the objectives for the unit.

Assemble the study materials. You will also need both the study unit you are working on and one of your set books on your desk at the same time.

Work through the unit. The content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit you will be instructed to read sections from your set books or other articles. Use the unit to guide your reading.
Up-to-date course information will be continuously delivered to you at the study centre.

Work before the relevant due date (about 4 weeks before due dates), get the assignment file for the next required assignment. Keep in mind that you will learn a lot by doing the assignments carefully. They have been designed to help you meet the objectives of the course and, therefore, will help you pass the exam. Submit all assignments no later than the due date.
Review the objectives for each study unit to confirm that you have achieved them. If you feel unsure about any of the objectives, review the study material or consult your tutor.
When you are confident that you have achieved a unit's objectives, you can then start on the next unit. Proceed unit by unit through the course and try to space your study so that you keep yourself on schedule.

When you have submitted an assignment to your tutor for marking, do not wait for its return `before starting on the next units. Keep to your schedule. When the assignment is returned, pay particular attention to your tutor's comments, both on the tutor-marked assignment form and the assignment. Consult your tutor as soon as possible if you have any questions or problems.

After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this Course Guide).

TUTORS AND TUTORIALS

There are some hours of tutorials (2-hour sessions) provided in support of this course. You will be notified of the dates, times and location of these tutorials, together with the name and phone number of your tutor, as soon as you are allocated a tutorial group.

Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties you might encounter, and provide assistance to you during the course. You must mail your tutor-

marked assignments to your tutor well before the due date (at least two working days are required). They will be marked by your tutor and returned to you as soon as possible.
Do not hesitate to contact your tutor by telephone, e-mail, or discussion board if you need help. The following might be circumstances in which you would find help necessary. Contact your tutor if you:

- do not understand any part of the study units or the assigned readings
- have difficulty with the self-assessment exercises
- have a question or problem with an assignment, with your tutor's comments on an assignment or with the grading of an assignment.

You should try your best to attend the tutorials. This is the only chance to have face to face contact with your tutor and to ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain the maximum benefit from course tutorials, prepare a question list before attending them. You will learn a lot from participating in discussions actively.

CONCLUSION

On successful completion of the course, you would have developed critical thinking and logical skills (from the material) for efficient and effective discussion a Anthropogenic impact on land. However, to gain a lot from the course please try to apply everything you learn in the course to term paper writing in other related courses. We wish you success with the course and hope that you will find it interesting and useful.

MAIN COURSE

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MODULE 1 CURRENT TYPES OF SOIL RESOURCES CONCEPTS

UNIT 1 USERS' CONCEPT OF DEFINITION OF SOIL AS A RESOURCE

CONTENTS

1.0 INTRODUCTION

A fundamental knowledge of soil as a natural resource is vital due to the current challenges facing humanity. Much of our life's activities are related to and influenced by the nature of the soil around us. It is important that we understand the soils on which we design, build and work on. Your knowledge of soil as natural resource will enable you to minimise the degradation and destruction of one of our most important natural resources.

The soil, as the upper layer of the earth's surface, supports the entire human race for food, fibre, water, road, building construction sites and waste disposal. This unit is a logical starting point for the whole course on Anthropogenic Impact on Land as the unit deals with the concepts of land users' definition of soil as a resource.

2.0 OBJECTIVES

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

- define soils from the concept of the different land users
- state clearly human uses of soil.

3.0 MAIN CONTENT

3.1 Definitions of Soil by Various Users

Simply, layman defines soil as the upper layer of the earth's surface. Different users or disciplines see soil and conceptualise it related to its importance to them, therefore influencing their definition of soil and creating slight variation in soil definitions.

i. **Agronomists** define soil as a dynamic natural body composed of mineral and organic materials in form of solids, liquids, gases and living organisms in which plants grow.

ii. **Soil Scientists** consider soil as the collection of natural bodies occupying parts of the Earth's surface that is capable of supporting plant growth and has properties resulting from the integrated effect of climate and living organisms acting upon parent materials as conditioned by topography over a period of time.

iii. **Geologists** on their own part hold a restricted rock weathering concept. They consider soil as a disintegrated and more or less decomposed rock material mixed perhaps with organic matter from plant decay.

iv. **Engineers** define soil as any unconsolidated material regardless of depth or mode of formation. To a highway engineer, soil is regarded as a material on which a road bed is to be placed.

v. **Chemist** referred to soils as the storehouse of chemical compounds.

SELF-ASSESSMENT EXERCISE

Compare any 2 definitions of soil.

3.2 Uses of Soil

Soils serve various purposes and benefits on the Earth and some of these include:

1) Soil helps sustain life on Earth—including yours and mine.
2) You know also that soil supports the growth of plants, which in turn supply food for you and feed for your animals.
3) Soil provides us with cotton for clothing and herbs for medicines.
4) Timber obtains from trees serve as roofing material and is used in constructing residential and school furniture.

5) It serves as a habitat for variety of living organisms, from microorganisms to small mammals.
6) The trees sustained by soil provide us with the oxygen you breathe.
7) It helps in purifying water as it drains through the ground and into rivers, lakes, and oceans.
8) Building residential houses, institutions, religious place of worship, schools, road and bridges are done on soil.
9) Soil decomposing organisms help recycle nutrients by breaking down the remains of plants and animals, releasing nutrients that living plants use to grow.

SELF-ASSESSMENT EXERCISE

List any four benefits derive from soil.

4.0 CONCLUSION

Though different users of soils have their different definitions, soil could be defined as the collection of natural bodies occupying parts of the Earth's surface that is capable of supporting plant growth and serve as foundation for buildings. Some of the benefits derived from soil include food, medicines, fibres, minerals and construction material.

5.0 SUMMARY

In this unit, we have learnt that:

- The different land users' such as agronomist, geologists, pedologists, chemists and a host of others have their different concepts of defining soil as related to their use concept.
- Man's existence is supported by soil, as it provides him with food, medicines, fibers, minerals and construction material.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define soil from the concepts of three (3) different land users.
2. You as man, what are five benefits that you derive from the soil?.

7.0 REFERENCES/FURTHER READING

Agbede, O.O. (2009). *Understanding Soil and Plant Nutrition.* Petra Digital Press, Nigeria. 300pp.

Brady, N.C. & Weil, R. C. (2005). *The Nature and Properties of Soils.* (13th ed.) India: Pearson Prentice-Hall Inc881pp.

Erebor, O. (1998). *Comprehensive Agricultural Science for Senior Secondary Schools*. Lagos: Johnson Publishers Ltd.

Iwena, O.A. (2002). *Essential Agricultural Science for Senior Secondary Schools.* Lagos: Tonad Publishers Ltd. Nigeria. 293pp.

UNIT 2 COMPOSITION OF SOILS

CONTENTS

1.0 INTRODUCTION

Soils are composed mainly of four major components: inorganic material, organic matter, water and air. These components relate together with plants and micro-organisms to form ecosystem. The understanding of the soil components and how they relate could serve as a tool in the sustainable use and management of soils. The unit deals with the various components of soil.

2.0 OBJECTIVES

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

- state the components of soil
- list the constituents of inorganic materials in soil
- explain the role of organic matter in the nature of soils
- describe state of water in soil
- explain factors influencing air and their role to soil living components.

3.0 MAIN CONTENT

3.1 Soil Composition

Soil is consists of a mixture of solid, liquid and gaseous material. The solid materials consist of organic and inorganic substance. The liquid is water and soil solutions, and gas is air such as oxygen which microbes and plant use in the respiratory process. Sand, silt and clay particles constitute the inorganic materials, whereas, decompose plant and animals make up the organic component. The organic and inorganic particles constitute about 50% of a soil's volume. The remaining 50%

comprises the total pore spaces (i.e. macro and micropores). The connectivity of the pores allows flow of water, air, microbes, soil animals and penetration of plant roots as a result of growth.

3.2 Inorganic Material

Inorganic component of soil comprises of sand, silt, and clay particles. These are materials that are less than 2.0mm in diameter. However, gravels and rocks occur occasionally in soils and are known to have diameter greater than 2.0mm. Sand particles are large enough to be seen without the aid magnification and give soils a gritty feel (0.05 to 2.00mm). Larger silt particles can barely be seen by the eye, and the smaller silt particles can be seen only with the aid of a microscope (0.002 to 0.05mm). Silt feels smooth when rubbed between the thumb and fingers and feels much like talcum powder or wheat flour. Clay includes the fraction smaller than silt and feels sticky and plastic when wet and hard when dry (< 0.002mm). Clay is the finest material and has the largest surface area enabling its retention of more moisture and nutrient compared to sand and silt. The separate particles can be determined through sieve analysis, hand feeling and sedimentation process.

3.3 Organic Material

Organic material consists of undecomposed and partially decomposed residues of plants and animals and the tissue of living and dead microorganisms. Soil fertility depends on a high content of organic materials as it contains appreciable quantities of nitrogen, phosphorus and sulfur which become available to higher plants as decomposition and mineralization take place. The decomposition of organic matter produces substances that make plant nutrients more available. Organic matter increases the water retention and improves the aeration of soils. It also contributes to aggregate stability through binding soil particles together, thus reduces soil erosion. Organic matter contributes to the dark color of soil.

Soils serve as habitat to large population of living organisms ranging from physical seen ones like earthworms, mites, millipedes, centipedes, termites and lice to microscopic ones like fungi and bacteria. Microbial organisms (bacteria and fungi) feed on dead plants and animals, aiding their decomposition and mineralisation for plant uptake as nutrients. For example, the process of nitrogen nutrient formation, involves conversion of ammonia to nitrite, and nitrite to nitrate. These processes involve different bacteria.

3.4 Soil Water

Quantity of water present in soils depends on the size of the pores and the potential (energy) to retain it. Coarse soil (sandy soil) with large pore space contains large volume of water, but will easily drain under gravity and leaving the space for air to occupy. This is because sandy soil is dominated by macro-pore space. Fine textured soils (clayey) may have small volume of water and easily flooded, but retains water for longer period of time. The challenge of using clay soil for crop production is poor drainage caused by long water retention and may result in flooding affecting crop aeration. Medium textured soils such as sandy loam, clay loam and sandy clay loam have good moisture retention and aeration as such soils have moderate proportion of both macro and micropores.

The ability of soil to retain water is what determines the availability of water to crop for their growth. Water movement through soil pores (micro-pores) independent of gravity is referred to as available water holding capacity (AWHC). Water movement under such condition occur via capillary action, in which water molecules move because they are more attracted to the pore walls than to one another. Such movement tends to occur from wetter to drier areas of the soil. Water movement from soil to plant roots depends on how tightly water molecules are bound to soil particles. The pressure influencing water movement into the roots is termed osmotic potential. The osmotic potential depends on the amount of dissolved salts in the soil.

3.5 Soil Air

Air and water compete for the soil pore spaces. Therefore, when soil is saturated with water and fills the pores, there is deficiency of oxygen and may result in plants death. Fertile soils permit an exchange between plants and the atmosphere, as oxygen diffuses into the soil and is used by roots for respiration. In turn, the resulting carbon dioxide diffuses through pore spaces and returns to the atmosphere. This exchange is most efficient in soils of medium texture such as sandy loam and clay loam that have good porosity. Animals like earthworms and other soil inhabitants burrow soils thereby providing a natural and beneficial form of aeration.

SELF-ASSESSMENT EXERCISE

Why should soil consist of solid, liquid and gaseous components?

4.0 CONCLUSION

Soil consists of a mixture of solid, liquid and gaseous materials. The solid material consists of organic and inorganic substances. The liquid is

water and gas is air. Sand, silt and clay particles constitute the inorganic materials, whereas, decompose plant and animals make up the organic component. Air and water occupy the soil pore spaces. Organic matter contributes significantly to increase in nutrients and water retention as well as improves the aeration of soils. It also contributes to aggregate stability through binding soil particles together.

5.0 SUMMARY

From this unit you have learnt that:

- Soil consists of solid materials made up of organic and inorganic substances. Air and water fills the soil pore spaces.
- Inorganic component of soil is made up of sand, silt, and clay particles that vary in size of less than 2.0mm in diameter.
- Organic materials consist of undecomposed and partially decomposed residues of plants and animals that influence the retention of nutrient and water.
- The amount of water retained by soil is dependent on its texture and micropores.
- Air and water compete for the soil pore spaces. Flooding causes poor drainage and depletes air, which may result in aerobic plants death.

6.0 TUTOR-MARKED ASSIGNMENT

1 Explain the material constituting inorganic component of soil and explain briefly how you can identify these materials.

2 List any four (4) benefits of soil organic matter as a component of soil.

7.0 REFERENCES/FURTHER READING

Agbede, O.O. (2009). *Understanding Soil and Plant Nutrition.* Petra Digital Press, Nigeria. 300pp.

Brady, N.C. & Weil, R. C. (2005). *The Nature and Properties of Soils* India:. (13^{th} ed.). Pearson Prentice-Hall Inc. 881pp.

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Soil Survey Division Staff. (1993). *Soil Survey Manual.* Washington, DC: Agric. Handbook. No 18. U.S. Gov. Print. Office. Handbook No.18. 437pp.

UNIT 3 SOIL PROPERTIES

CONTENTS

1.0 INTRODUCTION

Soils are formed through interactions of factors such as climate, parent materials, organic matter, and topography over a period of time. Different interactions of these factors through different processes result in soils with different physical, chemical and biological properties that distinguish them. Soil properties are essential in characterisation and mapping of soils for the purpose of soil survey and sustainable use. This unit introduces you to the properties of soils and how the properties affect soil use and management.

2.0 OBJECTIVES

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

- explain physical properties of soils
- explain chemical properties of soils

- state the role of organic matter and living organisms in the nature of soils.

3.0 MAIN CONTENT

3.1 Soil Physical Property

Soil physical properties depend on the amount, size, shape, arrangement and mineral composition of its particles. These properties also depend on organic matter content and porespaces. Physical properties of a soil greatly influence its use and behavior towards plant growth. This is because physical conditions of the soil are linked with plant support, root penetration, drainage, aeration, retention of moisture, and plant nutrients.

3.1.1 Soil Colour

Soil colour is one of the most easily recognised soil characteristics and is very clear in horizons of soil profile. Surface horizon colours are usually dark, moderately dark, light, to very light. Subsoil colours are classified as red, yellow, brown, gray, or mottled. Colour usually is a good indicator of organic matter content, moisture availability, and texture of a soil. Dark surface horizon is an indication of presence of organic matter. Light color shows low organic matter content, high sand particles or reduced iron or manganese oxide. Soil drainage refers to the movement of water through the soil layers or off the soil surface. A well-drained soil is red or brown in colour; a fairly drained soil is yellow in colour; and a poorly drained soil is gray in color. Subsoils with mottle indicate seasonal saturation with water.

3.1.2 Soil Texture

Soil texture refers to the relative proportion of particles (relative percentage by weight) of the three soil separates viz., sand, silt and clay or simply referred to as the size of soil particles. The soil separates are defined in terms of diameter in millimeters of the particles. Sand is 2.00 – 0.02mm, silt 0.02 – 0.002mm and clay less than 0.002mm. Coarse textured soils consist of sand and loamy sand. Medium textured soil consists of sandy loam, silty loam, loam, silty clay loam, and sandy clay loam. Fine materials are Sandy clay, silty clay and clay. Soil texture is determined by hand feeling on fields, sieve and hydrometer methods (laboratory).

Soil particle size is important because it affects water-holding capacity and workability of soil. Silt type soils erode very easily. Clay particle holds soil nutrients, influences soil acidity, and holds more moisture than sand or silt. Sand facilitates drainage and aeration. It allows rapid

evaporation, percolation and leaching of applied nutrients. Loam and Silt loam soils are highly desirable for cultivation.

3.1.3 Soil Structure

Soil structure is the arrangement of soil particles into aggregate shapes or 'peds.' Soil particle aggregation is important for increasing soil water movement, maintaining porosity, stability against erosion, and improving fertility and carbon sequestration. Soil structure is formed through the process of clay particles coming close together and is cemented with organic matter. The materials bind together into aggregates. Crop removal during harvest on the soil surface destroys aggregation and organic sources of cementation. The longer the soil is without a cover, the more destruction there is in the aggregates.

Soil structure is classified or graded base on size, strength and shape of aggregate formed. Soil aggregate strength is determined by measuring a soil's resistance to crushing. Soil has no structure if coarse soil particles fail to cling together (single grain structure) or if fine soil particles break into large cement-like clods (massive structure). Other descriptive grades of soil structure are weak, moderate, and strong. Common types of soil structure are single grain, blocky, platy, massive, columnar, prismatic, and granular.

Granular structure is characteristic of many surface horizons, particularly those with high organic matter content and biological activity. Larger peds, in the form of plates, blocks, or prisms, are commonly associated with the sub-surface horizons and are formed via shrink-swell processes and adhesive substances. As soil swells and then shrinks, cracks form around soil masses, creating peds. Peds are held together and in place through the adhesion of organic substances, iron oxides, clays or carbonates. Cracks and channels between peds are important for water, air, and transportation of nutrients. Finer textured soils usually have a stronger, more defined structure than coarser ones due to shrink/swell processes predominating in clay-rich soils and more cohesive strength between particles.

Soil structure influences infiltration rate of water. Soil with a single grain or granular structure possesses a rapid infiltration rate. Soil with a blocky or prismatic structure has a moderate infiltration rate. Platy and massive soil structures have slow infiltration rates.

3.1.4 Soil Consistence

Soil consistence refers to cohesiveness of soil or resistance to rupture. Consistence is described under wet, moist, or dry soil moisture conditions. When the soil is wet, consistence is described by degrees of

stickiness and plasticity. Under moist condition, soil tendency to break into smaller pieces is considered as it friability and firmness. Consistence of soil under dry conditions is characterised by degrees of hardness.

3.1.5 Soil Porosity

Soil texture and structure influence porosity by determining the size, number and interconnection of pores. Coarse-textured soils have many macro pores because of the loose arrangement of larger particles with one another. Fine-textured soils are more tightly arranged and have more micro pores. Soil texture affects porosity than structure. Long-term cultivation tends to lower total porosity because of a decrease in organic matter and large peds. Surface crusting and compaction decrease porosity and inhibit water entry into the soil.

3.1.6 Soil Water

Soil texture influences degree of porosity and affects water and air movement. When pores are completely filled with water, the soil is saturated and water drains freely from the soil through gravitational pressure. The amount of water remaining in soil after all gravitational water has drained is referred to as field capacity (FC). Remaining water is held in micropores via attractive capillary forces. Capillary water is retained in the soil and is the water available for crop use and is considered as available water holding capacity (AWHC) of soil. This water is available for plant uptake until the permanent wilting point (PWP). At PWP water is held too tightly by the soil and it is difficult for plants to extract it, thus plant wilt irreversibly. Well-aggregated, loamy soils are best suited for supplying plants with water because they have enough macro-pores to provide drainage and aeration during wet periods, and adequate micropores to provide water to plants and organisms.

3.2 Chemical Properties

3.2.1 Soil pH

Soil pH refers to a soil's acidity or alkalinity and is the measure of hydrogen ions (H+) in the soil. Low pH value indicates acid soil with high amount of H+ and high shows alkaline soil condition. Soil pH affects cation exchange capacity (CEC) by altering the surface charge of colloids. Soil pH is often referred to as soil reaction as it determines availability of nutrient elements.

3.2.2 Cation Exchange Capacity (CEC)

The ability of soil to adsorb and exchange ions is referred to as cation exchange capacity. Most chemical interactions in the soil occur on colloid surfaces because of their charged surfaces. Due to their chemical make-up and large surface area, colloids have charged surfaces that are able to adsorb ions within soil solution. Depending on the ion's charge, size and concentration in the soil, it can be held to the colloid surface or exchanged with other ions and released to the soil solution. Soils of the Tropics are dominated by negative charges and have overall (net) negative charges. Therefore, more cations are attracted to exchange sites than anions (negative ions). Fine-textured soils usually have greater exchange capacity than coarse soils because of higher proportion of colloids. Similarly, soils with high organic matter have greater CEC.

3.2.3 Soil Nutrients

Soil nutrients are elements essential for crop growth. Essential elements are grouped into two groups as macronutrients and micronutrients. Those required in large quantity for plant growth are considered as macronutrients and those required in small quantity is called micronutrients. Macronutrient elements include C, H, O, N, P, K, S, Na and Ca, while micronutrients are B, Cu, Fe, Mn, Mo and Zn.

3.3 Soil Biological Properties

3.3.1 Soil Biota

The soil environment is teeming with biological life and is one of the most abundant and diverse ecosystems on earth. Soil biota, including flora (plants), fauna (animals) and microorganisms, perform functions that contribute to the soil's development, structure and productivity. General characteristics and functions of these groups are presented below.

3.3.2 Soil Flora

Plants act on the soil environment by aiding improvement in structure and porosity, and in supplying organic matter through plant residue. Root channels can remain open for some time after the root decomposes, allowing an avenue for water and air movement. Roots also act to stabilize soil through aggregation and intact root systems can decrease soil loss. The 'rhizosphere' as the narrow zone of soil directly surrounding plant roots, is the most biologically active region of the soil. It contains dead root cells and secreted chemicals (i.e., sugars, organic acids) that provide food to soil organisms.

3.3.3 Soil Fauna

Soil fauna serve in initiating the breakdown of dead plant and animal material, thus increasing aggregation of soil particles. These soil animals are involved in ingesting and processing large amounts of soil. Their burrowing of soil creates pores for water and air movement as well as mixing soil layers. Important soil fauna include earthworms, insects, nematodes, arthropods and rodents. Earthworms are considered as one of the most important soil fauna.

3.3.4 Soil Microorganisms

Micro-organisms are very small (microscopic) organisms in soil affecting several soil properties. Soil microbes include bacteria, protozoa, algae, fungi and actinomycetes. Microbes aid soil structure by physically surrounding particles and binding them together through the secretion of organic compounds such as sugars. Bacteria are important in the decomposition of soil organic matter, transformation of nutrients and aggregation of clay. Rhizobia are bacteria that fixe nitrogen in soil through symbiotic association with legume roots. Fungi are known as wide range of microbial organisms in soil that are extremely important in the breakdown of organic matter and significant amount of aggregate stability.

3.3.5 Factor Affecting Biological Activity

Soil biological activity is controlled by many factors in the soil. Amount of nitrogen, quantity and quality of residue as well as soil organic matter are major limiting factors for soil organism activity. Other soil factors that promote activity of soil living organisms include adequate levels of oxygen, near-neutral pH and temperatures between 30-35°C.

Management practices can affect soil organism activity through changes in aeration and structure, cropping systems, and inputs. Applications of fertiliser can also influence populations and activities of soil organisms. Addition of fertilisers, particularly those containing nitrogen increases biotic activity in soils under low fertility and soil organic matter.

SELF-ASSESSMENT EXERCISE

Soil organic components play significant role in soil properties, explain.

4.0 CONCLUSION

Soil physical, chemical and biological properties affect the nature of soils influencing their suitability for agricultural practices and other purposes. Soil texture, structure, and porosity influenced the movement and amount of water retention, air and solutes in the soil, which subsequently affect plant growth and organism activity. Soil pH and

cation exchange capacity affect nutrient availability and biota growth. Biological properties contribute to soil aggregation, structure and porosity, as well as soil organic matter decomposition and mineralisation.

5.0 SUMMARY

You have learnt within this unit the following:

- Soil physical properties include features like soil texture, structure, bulk density, consistence, porosity, and their influence on nature of soils.
- Soil chemical parameters include pH, cation exchange capacity and nutrients.
- Effect of soil organisms and soil organic matter influence on soil properties.
- Effect of soil properties on soil management and crop production.

6.0 TUTOR-MARKED ASSIGNMENT

1 List any three features of soil physical properties and discuss how they influence nature of soils.
2 Soil chemical properties greatly affect soil fertility, discuss.
3 Explain the role of soil organisms on the nature of soils.

7.0 REFERENCES/FURTHER READING

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UNIT 4 SOIL CLASSIFICATION SYSTEMS

CONTENTS

1.0 INTRODUCTION

Soil classification is resourceful information developed to harmonise soil information across the world. This is because soil users face the problems of land degradation and disparity of production potentials, however, with soil classification, the transfer of technology related to soil management and land use planning is made possible.

Your understanding of soil classification will strengthen your ability to characterise soils as it is a necessary tool to soil survey and mapping for the purpose of sustainable use and planning. This unit introduces you to purpose and the various systems of soil classification.

2.0 OBJECTIVES

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

- state five reasons why we classify soils
- explain the two major forms of soil classification.

3.0 MAIN CONTENT

3.1 Purpose of Soil Classification

Soil classification is useful for the following specific purposes:

i. To organise useful and understandable information and knowledge on soils.
ii. Grouping of soils into classes help us to remember their names and important properties.
iii. Organising soils into groups with similar properties minimises the problem of locating information about any one soil.

iv. It makes us to easily understand the relationships among individual soils being classified.
v. Help us to predict soil behaviour and even estimate their productivity.
vi. By means of soil map, extrapolation of knowledge and information of one soil to others in other places by different soil scientists becomes possible.
vii. Helps us to identify the best use of a particular soil.

3.2 Types of Classification

Soil classification is based on two broad systems namely: Scientific and Technical classification.

3.2.1 Scientific Classification

Scientific approach to classifying soils as resource includes the **Soil Taxonomy** Classification system developed by United State Department of Agriculture (USDA) (Soil Survey Staff, 2010) and **World Reference Based Soil Resource 2006:** Food and Agricultural Organisation of UNESCO (FAO UNESCO, 2006).

a. USDA Soil Taxonomy Classification System

The USDA Soil Taxonomy classification system is based on soil formation process, stage or factors. The current system worldwide has six levels of classification. The **soil order** is the highest level and broadest group which are 11 in number. The soil order is divided into **suborder** which is further divided into **Great Group, Subgroup, Family** and **Series** which is the lowest soil grouping similar to **species** in animal and plant grouping (Soil Survey Staff, 2010). The **order** and **suborder** levels of soil classification are usually used at state and regional levels and by soil scientists. **Soil series** group is more relevant to farmers, builders, extension workers and those that require information on soils at local level.

Soil-forming processes as indicated by presence or absence of major diagnostic horizons. **Soil**

Order Description:

Entisols - Recently formed soils without pedogenic horizons like sand soils, alluvial soils, very shallow soils, etc.

Inceptisols - Embryonic soils with few diagnostic horizons. No accumulation of translocated materials other than carbonates or silica.

Aridisols - Soils of arid region such as desert soils. Some are saline.

Vertisols - Dark clay soils containing large amounts of swelling clay minerals (smectite). The soils crack widely during the dry season and expand, becoming very sticky in the wet season.

Mollisols - Grassland soils of Steppes and Prairies. Soils with nearly black, organic – rich surface horizons and high basic cation supply.

Spodosols - Soils with a bleached surface horizon (E Horizon) and an alluvial accumulation of sesquioxides and organic matter in the B horizon. These soils occur mainly under coniferous forests of temperate regions.

Alfisols - High base status soils with subsoil horizon accumulation of illuvial clay.

Ultisols - Low base status, highly leached soils with subsoil horizon accumulation of illuvial clay.

Oxisols - Sesquioxide-rich highly weathered and very highly leached soils of intertropical regions.

Andisols - Soils formed from volcanic materials often low in bulk density (<0.85g. cm-3), well-drained and high in allophane.

Histosols - Organic soils often termed peat or muck.

b. World Reference Based Soil Resource 2006

Food and Agricultural Organisation of UNESCO (FAO UNESCO, 2006) developed classification system for soil as a resource for agricultural purpose and soil management, and referred to it as *Soil Map legend of the world* (FAO, 1988) and currently referred to as **World Reference Based for Soil Resource 2006.**

The classification was developed to harmonize soil information across the world, because of the problems of land degradation and disparity of production potentials. It is developed as a framework through which existing soil classification systems would be correlated and harmonised. The classification system is based on soil formation processes. The World Reference Base (WRB) is limited to the first level only and has 32 Reference Soil Groups (RSG) with set of prefix and suffix qualifiers for detail soil classification.

3.2.2 Technical Classification

Technical approach of land evaluation is usually carried out to assess land potential for various kinds of use. It assesses their capability and suitability for specific land use type. The approach leads to developing of soil map showing land use type to which the soil have potential or

most suitable. Some of the purposes associated with conducting land evaluation include:

1) To predict consequences of alternative uses.
2) Resource inventory e.*g*. *Land Resource Studies* series of the UK Land Resources Development Centre.
3) Project feasibility.
4) Farm planning: allocation of land for different uses.
5) Management purpose.

The basic principle of land evaluation is the comparison of requirements for land use and land resources (qualities). This is because different land uses have different conditions and different limitations. Land evaluation approach is either by assessing their capability for general uses (arable and non-arable crops), or by assessing their suitability for specific use. The former is referred to as land capability classification system (Brady and Weil, 2005), whereas, the latter is known as land suitability classification systems (FAO, 1995). The system encourages most appropriate utilisation of soil for the suitable land use type and sustainable management of land resource. Some of the approaches developed by FAO includes: land suitability evaluation for rain fed agriculture and irrigation.

a Land Capability Classification System

The concepts used in land capability classification system are capability and limitations. Capability is the potential of the land for use in specific ways with specified management practices. Limitations are referring to land characteristics which have an adverse effect on capability and cannot be easily changed. Land is classified on the basis of permanent limitation and if any one limitation is of sufficient severity to lower the land to a given class it is allocated to that class, no matter how favorable all other characteristics may be. The land capability classification is devised by the United States Department of Agriculture Soil Conservation Service since in the 1950s (Brady and Weil, 2005).
The structure consist of capability classes I (best) – VIII (worst). Classes I – IV for arable crops while classes V – VIII for non arable land use. At the subclass level lower case alphabet are used to designate limitation warranting the classification (e – erosion, w – wetness, c – climate, s – soil depth, etc.

b Land Suitability Classification System

The system of classification assesses land for its suitability for specified kind of use. Some of the major kinds of uses include rainfed agriculture, livestock production, and specific crop e.g. maize, cowpea, cotton, tomato, etc. The system involves assessment, classification and

mapping. In carrying out land suitability assessment, it involves defining the land use type, conducting soil survey to obtain land characteristics and obtaining land use requirement. The land use requirement parameter (data) is matched with land qualities of each soil (soil mapping unit) to obtain land suitability class for each quality. The ratings are summed up to provide overall suitability class and the critical conditions that most limit the class are assigned to the class to obtain a subclass level. Several approach have been used to obtain overall suitability class, amongst them are arithmetic mean, limiting condition method and multiplication (Dent and Young, 1981).

The structure of land suitability classification include two order namely suitable (S) and not suitable (N). Class levels include highly suitable (S1), moderately suitable (S2), marginally suitable (S3), currently not suitable (N1), permanently not suitable (N2) and not relevant (NR). Sub-class level reflects different kinds of limitations. At subclass level, lower case letters are used in designating the classification. Different units of a sub-class reflect minor differences in production characteristics or management requirements and Arabic numerals are values use in differentiating various units.

SELF-ASSESSMENT EXERCISE

Distinguish between the two major forms of soil classifications.

4.0 CONCLUSION

Soil classifications help us to have organized useful, understandable and harmonized information and knowledge on soils. World Reference Based Soil Resource 2006 developed by Food and Agricultural Organisation and Soil Taxonomy Classification system developed by United State Department of Agriculture (USDA) are the most widely used scientific classification system. In technical classification of soils, land capability classification (LCC) and land suitability classification are widely in use with different modifications.

5.0 SUMMARY

You have learnt within this unit:

- The importance of grouping soils into classes in order to remember their names and important properties. The grouping of soils also helps to have organized useful and understandable information about soils for worldwide harmonization of information and agricultural technology.
- Scientific and technical forms of soil classification systems.

6.0 TUTOR-MARKED ASSIGNMENT

1. State any five reasons why it is essential to classify soils.
2. Explain scientific and technical approaches to soil classification.

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UNIT 5 EARTH NATURAL RESOURCES

CONTENTS

1.0 INTRODUCTION

The earth is full of different natural resources that we use daily. The resources are valuable material obtained from the earth environment either from the atmosphere or from geological rocks. Some of these natures given resources are renewable, while others are non-renewable, and this calls for their sustainable use.

2.0 OBJECTIVES

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

- identify different natural resource around you
- group earth resources base on their source, uses and state of renewal.

3.0 MAIN CONTENT

3.1 Earth Natural Resources

From our definition of land in Unit 1 of this Module, we considered land to consist of resources within the Earth, surface of the Earth and atmosphere. Some common examples of these resources are:

- Soil
-Water
- Air (wind)
-Sunlight
-Trees
-Petroleum
-Minerals (gold, silver and diamond)

-Metals (iron, copper, zinc, aluminum, etc).

3.2 Forms of Resource

3.2.1 Renewable and Nonrenewable Resource

a. Renewable resources

These are natural resources that in used undergo depletion and can be replaced through natural processes at a rate that is equal to or greater than the rate at which they are loss. An example is cutting down of trees for fuel wood and there replacement through tree planting program to avoid deforestation. Others include sun, wind and water.

b. Nonrenewable resources

These are earth's natural resources that are extracted and we use on daily basis. Such resources are exhaustible and without renewal. In Nigeria a valuable resources of geologic origin that have been extracted from the earth is petroleum oil, and the fear is that the oil will deplete in the near future. Minerals such as gold, silver, diamond and platinum, along with metals found in earth are nonrenewable.

SELF-ASSESSMENT EXERCISE

Nature given resources are either renewable or non-renewable; identify two each within your community.

3.2.2 Energy Resources

Energy resources are the Earth natural resource exploited for the purpose of providing energy for human utilisation**.** In Nigeria, a major natural resource relied on is petroleum fuel. Petroleum is formed within earth and is refined into petrol, kerosene, grease, and diesel gas to produce heat, electricity and move mechanical systems. Coal and uranium are other earth natural resources that provide fuel energy. Electrical and mechanical energy are forms of energy derived from sun (solar), water reserved in dams (hydro-power) and wind.

3.2.3 Metallic and Nonmetallic Resources

a. Metallic resources

Metallic elements extracted from earth are valuable resources use in our modern society. We used them for roofing sheets (aluminum and zinc), concrete work (iron rod), and vehicle body (iron). Copper and aluminum are metal wires we use for electricity, whereas silver and gold as jewelries.

b. Nonmetallic resources

Soil is a natural resource that plant grows on it and indirectly provides food for man and his animals on Earth. Natural resources like granite, sandstone, lateritic stone and other types of bedrock formed within earth serve for the purpose of build our schools, homes, churches, mosques and other institutions. We use the calcite mineral to produce the main ingredient in manufacturing cement and lateritic soil (red clay) to make bricks. The common sand on the surface of the earth have been of great benefit to us in molding bricks for building, similarly we have enjoyed gravels in everyday civil construction works like foundation, road and bridges.

SELF-ASSESSMENT EXERCISE

List 6 resources you know and separate them into renewable and nonrenewable group.

4.0 CONCLUSION

Some of the earth natural resources around us are sun, wind, petroleum, granite, gold, iron and zinc. These resources are either sourced from the atmosphere or from geological origin.

5.0 SUMMARY

In this unit, we have learnt that:

- Earth resources are obtained from natural source and free.
- Resource may be obtained from geological or atmospheric source.
- Resources are either renewable or non-renewable.
- Natural resources are key source of energy for our utilisation.

6.0 TUTOR-MARKED ASSIGNMENT

1 List five natural resources you can see around you.
2 What is the implication of you having some of your resources being renewable and others non-renewable.
2 List three each of renewable and others non-renewable resources.

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MODULE 2 LAND USE AS RELATED TO SOILS

UNIT 1 MEANING OF SOIL AND LAND

CONTENTS

1.0 INTRODUCTION

Human beings were created from the dust (soil) as stated by the religious books and from that creation you depended on soil for survival and prosperity. To a certain degree good soils are also dependent upon people and the use they make of their soils. Your use of soils and land as a natural resources depend on your knowledge of these resources.

2.0 OBJECTIVES

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

- define soil
- define land.

3.0 MAIN CONTENT

3.1 Definition of Soil

Soil is defined as the collection of natural bodies occupying parts of the Earth's surface that is capable of supporting plant growth and that has properties resulting from the integrated effect of climate and living organisms acting upon parent materials as conditioned by topography over a period of time.

3.2 Definition of Land

Land is defined as the total natural environment or resource covering areas of the earth and includes: soil, minerals, forests, water surface and climates. All resources that exist naturally and contribute to your farm production are considered as land.

Land is considered as the most important factor of agricultural production, because without it no agricultural production can take place. Land varies across the Earth and therefore greatly influences the production of crops and rearing of animals. What you can produce on a piece of land depend on several factors such as:

i. climatic condition of the area
ii. nature of the soil fertility
iii. topography (slope characteristics)
iv. quantity and quality of the resources applied
v. cultural practices
vi. nearness of the farm to the available market.

SELF-ASSESSMENT EXERCISE

What is the difference between land and soil?

4.0 CONCLUSION

Soil is a natural body occupying part of the Earth's surface, whereas land encompasses soil and other natural resource.

5.0 SUMMARY

You have learnt the definitions of soil and land. You have also learnt that land include soil, climate, water surface, vegetation and minerals.

6.0 TUTOR-MARKED ASSIGNMENT

Using definitions, distinguish between soil and land.

7.0 REFERENCES/FURTHER READING

Agbede, O.O. (2009). *Understanding Soil and Plant Nutrition.* Petra Digital Press, Nigeria. 300pp.

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UNIT 2 USES OF LAND

CONTENTS

1.0 INTRODUCTION

Human society enjoys and uses the plants that grow on the soils for the supply of food and much of our fibers. Most of the clothing materials, medicines, drugs and animals needed for man's survival comes from plants and soil organisms. Apart from land assign for agricultural purpose, land can be put into other uses. These other uses may directly or indirectly assist farmers in their farming activities. This unit covers land utilisation types for agriculture and non- agriculture.

2.0 OBJECTIVES

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

- list four agricultural benefits derive from land
- list five non-agricultural benefits derive from land.

3.0 MAIN CONTENT

3.1 Agricultural Uses of Land

a) Crop production

The most important use of land for agricultural purpose is the cultivation of crops. Such crops include: food crops, vegetables, tree crops, fruits and fiber crops. Soil is the main source of plant nutrients that are essential for crop growth. These nutrients are transformed from unavailable forms in solid minerals and organic matter to readily available nutrient ions in soil solution to exchangeable sites associated with soil colloids and finally for plant uptake. Land serve as a growth medium for plant by supplying water, air and mechanical support for plant roots.

b) Animal production

Animal production requires the use of land for rearing and sheltering livestock. For large animal like ruminant goat, sheep and cattle land is required for production of pasture and forage to feed the animals in pen. In some places animals are allowed to graze on nature pasture.

c) Fish Production

Natural water has served as habitat for fish growth. However artificial lakes and ponds are constructed by man on land for the purpose of rearing different stock of fish to contribute as source of meat for man.

d) Forestry

Forestry involves use of large hectares of land to the establishment of agricultural trees. Areas found not suitable for arable crops production during soil surveying are marked and converted to forest. Generally, forest can be established in poor land, e.g. eucalyptus trees, date palm, mango, cashew, gum Arabic tree and neem trees. It helps in land conservation by acting as mulch and reduces soil degradation from rain causing soil loss through erosion process. The fruits harvested from the trees are either consume or sold in the market as a source of economy to the farmer. Forest trees have served as herbal product in curing several ailments across the world.

e) Wildlife Conservation

Wildlife conservation is necessary to preserve some species of wild animals and prevent them from extinction. Wildlife conservation parks serve as habitat for several living organisms including micro-organisms, reptiles and even mammals, which in turn help in improving soil structure and fertility. In Nigeria several large span of land are reserved for wildlife conservation such as Yankari Game Reserve, Falgore Game Reserve, Kamuku Park, Lake Kainji Park, Obudu Ranch and Gembu Park.

3.2 Non-Agricultural Uses of Land

Some land utilisation types apart from agriculture include the following:

a. Residential Building and Industries

Land is required for the building of residential houses and industries. The expansion of these houses gives rise to villages and villages develop to urban settlements (towns and cities). Residential buildings take substantial part of agricultural land especially in urban settlements. Soil

is an important building material use in form of earth fill and baked bricks. When land serve as foundation materials which houses and factories are built upon, it determines whether the structure will last.

As population increases in towns and cities, so there is the need to build-up industries to meet the needs of the people. In Nigeria there are thousands of industries scattered all-over the country. Each industry require tangible portion of land for their establishment. ii. The foundations of houses and factories thus determining whether the foundations are adequate. Soil is an important building material in form of earth fill and baked bricks. Land materials are also used in making pots, jugs, plates and other household usable structures.

b. Institutions

A lot of land is occupied by both civil and religious organisations for the establishment of institutions, schools, churches and mosques are established in all villages, towns and cities throughout Nigeria. These require land wherever they are sited.

c. Roads and Bridges

Land is the material on which our roads and bridges are constructed to serve our means of transportation. Apart from roads and bridges constructed on land, railways linking one state to another and one town to the other occupy millions of hectares of land. Solid and good foundational material for building roads and highways are also exerting strong influence on the life span of these structures. The engineering uses of soil demand knowledge of the diversities of soil properties which vary from one location to another.

d. Parks and Recreational Centre

Amusement parks and recreational centers such as football field, swimming pools and other recreational centers occupy a lot of land area.

e. Waste Dump Sites

Land serves as adsorbing medium to domestic wastes through septic sewages system. It provides waste dump site and landfills for other wastes from industrial, municipal and animal sources.

SELF-ASSESSMENT EXERCISE

Enumerate benefits derived from land in both agricultural and non agricultural forms.

4.0 CONCLUSION

Land serves man's variable purpose from agricultural crop and animal production to foundation for buildings as well as sites for waste disposal.

5.0 SUMMARY

From this unit, you have learnt:

- Agricultural benefits of land such as: crop, animal, fish and forest production.
- Non-agricultural benefits of land including road, houses and waste dump sites constructions.

6.0 TUTOR-MARKED ASSIGNMENT

State clearly four agricultural uses of land and four non-agricultural uses of land.

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UNIT 3 LAND USE AND LAND COVER CHANGE

CONTENTS

1.0 INTRODUCTION

Human activities in agricultural and non-agricultural forms have greatly impacted soil properties. Some of the impacts are either negative or positive. Land uses are mostly carried out either for agriculture, mining or development of infrastructures. Therefore land degradations and loss of biodiversity associated with land use are not intentionally done. However, your knowledge of land use and their associated land cover changes may contribute to sustainable use and management of these resources rather than degrading them.

2.0 OBJECTIVES

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

- explain clearly the changes occurring on land surface caused by changes in land use
- state factors influencing land use and land cover change
- explain the effect of land use on land cover change.

3.0 MAIN CONTENT

3.1 Land Use and Land Cover Change

Land use and land cover is an important component in understanding the interactions of human activities with the environment and therefore it is necessary to monitor and simulate changes.

Several human activities have had pronounced impacts on soil properties. For instance afforestation using Conifer has caused significant decrease in soil pH through acid deposition and in the quality and turnover of organic matter. Acid deposition has also increased the mobility of trace metals in the soil and therefore increased metal concentrations in drainage water. Sewage sludge deposition in soils has

increased metal concentrations in soils. Intensive cultivation of arable crops in lowlands has reduced organic matter concentrations, structural stability and soil workability, and has greatly affected soil erodibility. Human trampling of vegetation affects the nature of soils as the protective vegetative cover is destroyed and soil exposed to erosion processes.

Increase in mono-cropping of arable crops has probably the greatest potential detrimental impact on soil systems as it decreases soil organic matter concentrations. This is because large span of natural forest contributing organic matter is cleared and the land exposed to deforestation and desertification. The general trend towards more intensive and industrialized agriculture in develop nations like Europe has a profound impact on the environment, including emissions to air and water, quality and quantity of surface water and groundwater, soil erosion, pollution due to large-scale use of pesticides, and loss of biodiversity and habitats. Animal rearing increased soil erosion and siltation into water body such as Lake Chad. Reservoir capacity is reduced and water dry within short period, therefore not able to sustain the vast agricultural activities taken place within such basin.

Land use change is an important driver of biodiversity change as natural areas are converted to agriculture or urban areas. Key factors causing the decline in biodiversity include habitat disturbance and changes in the food chain. Agriculture has a significant role in non-point source pollution. Loading of waters is caused by crop and grassland production and livestock production. Phosphorus and nitrogen leach to rivers increased oxygen consumption and consequent oxygen depletion through eutrophication process, and, finally death of aquatic organisms.

The ecosystem in urban communities differs from natural or rural ones in many ways. Human activities such as building, traffic, or industrial production in urban areas affect the quality of air, water, and soil which impacts ecosystems in many ways. Plants can be destroyed or their production reduced drastically. Therefore increase in human population density in urban communities alters species composition, changes urban flora and vegetation. It also causes decrease in native species and brings about the introduction and naturalization of non-native plants. Cities located near rivers cause changes by the development of run-off following urbanization of the catchment. The water experience pollution and result in decrease in biotic communities. Sandy soils can become more acidic due to the loss of calcium in the groundwater. The filling of swamps for construction in places such as Lagos, Port-Harcourt and other major cities have blocked the main river systems and thereby increased periodic flooding of the cities. One other unavoidable impact of land conversion for urban development is the loss of prime agricultural land. With dam constructions, it usually brings along

detrimental impacts of water resources development on land cover and land use practices in flood plains. Several hectares of land will become inundated and the natural vegetative cover will be replaced with swamp or floodplain vegetation.

3.2 Factors Influencing Land Use and Land Cover Change

1. **Water resources development projects** are known to greatly alter hydrology of surrounding floodplains or communities through flooding which destroy their homes. Buildings in floodplains were inundated with floodwaters for several months of the year in places like Numan, Yola and Markudi along river Benue in Nigeria. These hydrological impacts were further exacerbated by release of water from a dam in Cameroon.

2. **Natural geomorphological processes** bring change in response to the natural processes of erosion and sedimentation. Shifts in channel morphology near the coast have been described.

3 **Drought cycles** causes invasion of vegetation. For example, open floodplain grasslands have been replaced by palm savanna, and flood-tolerant wetland species are displaced by more upland species. Similarly, freshwater grasslands are replaced by more saline grasslands, drying out of abandoned alluvial channels and salinisation of wetland soils. Loss of floodplains and fish are also associated with drought cycles.

4 **Economic development**
Slash and burning practices are common for clearing agricultural fields, removing forest cover and reducing soil fertility. Land cover in the delta area has experienced change to rice agriculture with the world rapid population growth and demand for food like rice. Commercial sugar plantations have also profoundly changed the delta landscape.

5 **Civil wars** result in death, displacement of people and their migration. Agriculture is either disrupted or agricultural fields abandoned and reverted to secondary grassland, savanna and thicket. Wildlife populations, on the other hand face devastation by hunting operations resulting in d**ecrease** in wildlife populations.

6 **Increase in frequency and its extent of fire** on forest vegetation is great and intimately connected with patterns of human activity. Late dry season fires, originating in wooded grasslands, sweeping into open woodland and woodland communities have resulted in destruction of shrubs and small trees and sometimes canopy components.

3.3 Implications of Land Cover and Land Use Change

Conservation of Biodiversity

Forest areas with abundance of water have diverse and abundant wildlife populations supported by the high productivity of vegetations. In some of such areas, zebra and hippo are on the brink of local extermination, and other mammals have withdrawn from their normal habitats to avoid being killed by wild hunters. Grasslands are invaded by woody vegetation and thickets, and drought-resistant grassland species replace wetland species of higher nutrient content. Animals such as buffalo are most susceptible to starvation and high mortality when their pastures dry out early in the dry season, especially when uncontrolled fires sweep across the forest land. Therefore, there is need for conservation measures to protect the biodiversity.

Human welfare

Water resources development projects, drought cycles and civil war have also had a marked effect on human welfare. Land use changes affecting local communities include loss of floodplain agriculture, reduced livestock grazing and carrying capacity, loss of floodplain fisheries, changes in natural resource utilisation patterns and reduced wildlife hunting.

Local livestock holdings, especially cattle and goats have their large proportion being killed during civil wars. Fish are the most important source of protein for riverine people e.g. Niger Delta and Baga in Lake Chad areas, especially during times of food shortage.

SELF-ASSESSMENT EXERCISE

Distinguish between the positive and negative changes associated with land use.

4.0 CONCLUSION

In this unit, you have learnt about land use and changes associated with it. Some of the positive changes include afforestation and organic matter accumulation, whereas the negative ones include erosion, siltation and loss of biodiversity.

5.0 SUMMARY

You can summarise the main points in this unit as follows:

- land use change are associated with factors such as development projects, urbanisation, mono-cropping, civil war, drought cycle, flooding, etc.
- land use change influences biodiversity conservation and human welfare.

6.0 TUTOR-MARKED ASSIGNMENT

1 Discuss anthropogenic effects on land cover change.
2 Enumerate any four (4) factors contributing to land use and land cover changes.

7.0 REFERENCES/FURTHER READING

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MODULE 3 INTERACTION TECHNOLOGY IN SOIL ENVIRONMENT

UNIT 1 CONCEPT OF INTERACTIVE TECHNOLOGY CONTENTS

1.0 INTRODUCTION

Organic and inorganic materials accumulate in soils through natural processes and human activities. This organic matter may accumulate to a level considered to be organic contaminants in soils. These materials do not exist in isolation, but interact in soils along with the microbial organisms. The interaction influence organic and inorganic substance status and movement, as well as determine their bioavailability and toxicity in the environment. The interaction influences the health status of the soil which determines how sustainable the environment will be. Your knowledge of the concept of interaction technology will contribute to sustaining soil environment which serve as life storage system.

2.0 OBJECTIVES

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

- explain concept of interaction in soil environment
- explain clearly the forms of interaction in soil environment.
- enumerate the benefits of interaction between community of microbes and plant rhizosphere.

3.0 MAIN CONTENTS

3.1 Concept of Interaction in Soils

Natural process and anthropogenic activities causing accumulation of organic and inorganic materials lead to formation of contaminants. The contaminants are in forms referred to as heavy metals and organic contaminants. Such materials do not exist in isolation in soils, but in complex mixtures and interact in soils along with the microbial organisms. The interaction influence metallic and organic substance status and movement, as well as determine their bioavailability and toxicity in the environment.

3.2 Source of Interacting Materials

Materials interacting in the soil environment originate from natural processes and anthropogenic activities. Geological process is the natural weathering of rocks into primary minerals that contain elements in immobile state. The primary minerals may weather into secondary clay mineral that releases mineral elements with some that are cationic and may be referred to as heavy metals. When plants and animals die, they decompose and contribute to soil organic matter. This organic matter may accumulate to a level considered to be organic contaminants in soils.

Anthropogenic activities involve agricultural processes of crop and animal production that requires input such as fertilisers, pesticides and herbicides application, as well as animal feed and feaces that are collected as waste to serve as soil amendments. In urban settings, some of the human activities releasing contaminants to the environment are domestic, hospital and industrial waste and sewage, as well as industrial and automobile emissions. Some of the complex mixtures include lead (Pb), copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), arsenic (As), cadmium (Cd) and mercury (Hg). Others from organic contaminants include petroleum hydrocarbons, polychlorobiphenyls, polycyclic aromatic hydrocarbons, dioxins and furans, phthalic acid esters and chlorinated solvents (Wuana et al., 2014).

SELF-ASSESSMENT EXERCISE

Enumerate sources of organic and inorganic substances interacting in soil environment.

4.0 CONCLUSION

Geological weathering of rock is the main natural process accumulating materials in soils for interaction. Materials released from human activities are sourced from agricultural processes of crop and animal production that requires input such as fertilisers, pesticides and herbicides application, as well as animal feed waste. Anthropogenic activities in urban areas in forms of domestic, hospital and industrial waste and sewage contribute to deposition of materials in soil for interaction.

5.0 SUMMARY

From this unit, you have learnt that:

- Materials dump in the soil environment are not static or exist in isolation, but interact in the soil environment.
- The materials are sourced through natural process such as rock weathering and anthropogenic activities like agriculture, industrial and residential wastes.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the fate and sources of material interacting in soil environment.

7.0 REFERENCES/FURTHER READING

Wuana, R.A., Okieimen, F.E. & Vesume, R.N. (2014). "Mixed Contaminant Interactions in Soil: Implications for Bioavailability, Risk Assessment and Remediation". *African Journal of Environmental Science and Technology*. 8(12): pp 591–706. http://www.academicjournal.org/AJEST.

UNIT 2 FORMS OF ORGANIC AND INORGANIC MATERIALS INTERACTION

CONTENTS

1.0 INTRODUCTION

Metals are found in soils from weathering of rocks and may be contributed through dumping of industrial and urban domestic wastes. Organic substances may be deposited in soils from residues of dead plants and animals, and hydrocarbon compounds of petroleum products, industries and other related wastes. The interaction between metals and metals, organic-organic compounds and between metal and organic compounds are influenced by the characteristics of soil environment such as pH, cation exchange capacity, amount and type of organic matter and sesquioxides.

2.0 OBJECTIVES

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

- explain metal and metal interaction in soil environment
- explain organic substances interaction in soil environment
- explain metal-organic substances interaction in soil environment.

3.0 MAIN CONTENT

3.1 Interaction of Metals in Soil

Metallic elements such as heavy metals occur in soils in low mobility state as elements incorporated in precipitated oxides and hydroxides, and insoluble salts. Low mobility metals are also found to be fixed in clay mineral crystal lattice and primary minerals after been weathered or decomposed from parent rocks. Metals in soil as structural components of secondary minerals and other inorganic compounds are usually of

medium mobility status. Low to high mobile metals form ions complexed or chelates by organic colloids and elements in decomposing organic material as well as soil biomass. Metallic elements occurring in form of soil solution as ionic molecules, chelates or colloids are usually found to be highly mobile. Similarly, ions at the exchange interface and readily exchangeable ions in inorganic and organic fractions are highly mobile.

The interaction of metals in soil may not be easily generalised, but the factors that influenced their interaction and the characteristics of their environment which are used in determining their fate and effect can be generalised. In contaminated soils, the input of heavy metal is mostly in non-silicate bound forms and is available for physical, chemical and biological modifying influences. Therefore, the introduction of contaminant in soil as heavy metals eventually leads to changes in their chemical forms, distribution, mobility and toxicity. The interaction of heavy metals in soils lead to their bioavailability (level of exposure of organisms to heavy metals relative to their speciation in soil systems), and can be used to estimate risk to ecological system and human health.

Soils containing clay minerals are more effective in adsorption of heavy metals than sand. This is because clay carries Fe, Mn and Al oxides. However Fe and Mn oxides have more adsorptive capacity than Al in soils. Soil pH is a key factor in that determining adsorption of heavy metals like Cu, Cd, Cr, Hg, Ni, Pb and Zn. Humic substances are part of soil organic matter that strongly adsorbs heavy metals reducing their solubility and mobility in soils. Soil microorganisms including bacteria and fungi contribute in reducing heavy metal effect in soil environment as can interact (bio accumulate) with heavy metal through bio sorption, absorption and uptake. For example, soil microbes can take up heavy metal ions and metabolically convert them into harmless forms by either complexation or precipitation.

Interaction of metals in soils could be natural as they occur in specific mineralogical associations due to similarity in physical and chemical properties of their elements. For example, Zn ore contain Pb and Cd. This implies that one element rarely serve as soil contaminant. Competitive interaction occurs among metals bearing equal number of cations as they have structural similarities and therefore strongly affect their adsorption on surface of soil matrix. Competitive interaction influence selective adsorption of some metals (e.g. Cr, Cu and Pb) and

displacement of others (e.g. Ni, Cd and Zn). Selective interaction is often factored by status of metallic cation and soil physical and chemical properties such as texture, pH and cation exchange capacity (CEC).

SELF-ASSESSMENT EXERCISE

Explain the factors influencing metals interaction in soil environment.

3.2 Interaction of Organic Materials in Soil

Soil organic matter especially from anthropogenic activities when accumulated in soils can become contaminants to the soil environment and regarded as organic contaminants. Their interaction in soils is influenced by soil characteristics, compound properties and environmental factors such as precipitation (rain), sunshine and temperature. In soils, accumulated organic materials which become organic contaminants may undergo processes such as leaching, volatilisation, photo-degradation and adsorption.

Competitive interaction also occurs between mixtures of organic contaminants in soil as with metals. The process results in displacement of an adsorbed organic contaminant into soil solution by another. This may be caused by their structural similarity and other physical and chemical properties. Some examples of organic contaminant in soils from pesticides and herbicides include: 1, 2, 4- trichlorobenzene (1, 2, 4-TCB), tetrachloroethene (TCE), atrzine, pyrene, sulfonamides, surfactants, dichlorobiphenyl and chrysene.

3.3 Interaction of Metal-Organic Materials in Soil

Soils containing materials dumped or placed from anthropogenic activities as well as crop and animal residues usually contain mixtures of both inorganic (metallic) and organic materials. Micro-organisms use organic materials (contaminants) as source of carbon or may transform them into non-toxic substance, but the process can be inhibited by the presence of heavy metal in the mixture. Interactions of metals and organic substances to form chelates have contributed in reducing toxic effect of strongly complex metals. This is because organo-complex metals are less toxic to organisms than the free ions. Interaction of mixture of metals and organic substances have influenced movement of heavy metals in soils as metals form association with mobile colloids and possibly with metal organic complex that is not adsorbed on surface of soil particle.

4.0 CONCLUSION

Metallic substances introduce in soils interact and this leads to changes in their chemical forms, distribution, mobility and toxicity. The interactions of heavy metals in soils influence their bioavailability. Organic materials accumulated in soils undergo processes such as leaching, volatilisation, photo-degradation and adsorption. Interactions of metals and organic substances to form chelates have contributed in reducing toxic effect of strongly complex metals as organo-complex metals are less toxic to organisms than the free ions.

5.0 SUMMARY

From this unit, you have learnt that:

- Metals interaction in soil environment is influenced physical and chemical properties such as texture, pH and cation exchange capacity.
- Structural similarities and other physical and chemical properties influence organic substances interaction in soil environment.
- Organic materials may undergo processes such as leaching, volatilisation, photo-degradation and adsorption in soils.
- Formation of chelates renders toxic metals to be less toxic in soils.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss how metal-metal and metal-organic substance interact in soils.
2. Enumerate benefits of metal-organic substance interaction in soil environment.

7.0 REFERENCES/FURTHER READING

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UNIT 3 INTERACTION OF MICROORGANISMS

CONTENTS

1.0 INTRODUCTION

The need to increase yield and sustainability of crop production is one of the biggest challenges facing agriculture today as the world population is growing rapidly. To increase the yield of basic food, additional inputs for crop production are needed and new technologies are essential for managing soil nutrients as well as crop pests and diseases. Microbial communities are essential in cycling of nutrients and influencing of soil quality. Rhizosphere is one of the most complex environments that thousands of interactions takes place and plays a crucial role in the health of plants. The understanding of the rhizosphere as a critical interface for soil and plants has contributed to tackling the challenges faced by rapid population growth, food security and climate change.

2.0 OBJECTIVES

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

- explain the nature of microorganisms communities
- mention three methods use in studying microorganisms communities
- explain interaction between community of microbes and plant rhizosphere.

3.0 MAIN CONTENT

3.1 Communities of Micro-organisms

Soil micro-organisms play an important function in cycling of nutrient elements through decomposition and mineralisation of organic material, which are released into the soil as nutrient elements that are essential for plant growth. The communities of microbes can influence nutrient availability through process of solubilisation, chelation, and oxidation/reduction. Soil microorganisms can release growth stimulating

or inhibiting substances that may affect nutrient uptake thereby influence root morphology, growth and function. Where growth is inhibited, microbial inoculants promoting plant growth can be used as they enhance nutrient availability and uptake, and improve plant health.

Knowledge of soil microbial community will help in understanding how soil cultivation (tillage systems) practices can be improved for enhancing soil quality.

3.2 Methods of Studying Microbial Communities

Microbial community influences soil quality. The status and rapid changes occurring in soil quality can be monitored by robust indicators. The rapid response to disturbances of microorganisms serve as an advantage to studying them, as their rapid change may provide instant information about soil health. The recent techniques developed to study microbial communities are based on new molecular, enzymatic, and organism-based techniques. The methods of studying microbial communities are grouped based on their ability to identify microbial biomass, diversity or activity.

a) Microbial Biomass

Chloroform Fumigation-Extraction (CFE)
Phospholipid Fatty Acid Analysis (PLFA)

b) Microbial Diversity

Denaturing Gradient Gel Electrophoresis (DGGE)
Single-Strand Conformation Polymorphism (SSCP)
Terminal Restriction Fragment Length Polymorphism Fingerprinting (T-RFLP)
Automated Ribosomal Intergenic Spacer Analysis (ARISA/RISA)
Random Amplified Polymorphic DNA (RAPD)
Amplified Ribosomal DNA Restriction Analysis (ARDRA)
Fluorescence In Situ hybridization (FISH)

c) Microbial Activity

Fluorescein Diacetate (FDA)
Stable-Isotope Probing (SIP) (Rincon-Florez et al., 2013).

3.3 Interaction between Rhizosphere Plant and Microbes

Rhizosphere is one of the most complex environments that serve as an interface for soil and plant roots. It contains thousands of interactions that play crucial roles for plant health. Large amount of photosynthetic

products are release to the roots into the rhizosphere. The photosynthate secreted supply carbon that is considered deficient in the soil, thus rapidly increasing the microbial densities 1000 times, compared to bulk soil. The exchange of nutrients between the plant and the different communities surrounding the root increased concentration of microorganisms in the rhizosphere allowing different types of associations. Factors influencing the quantity and quality of root substance secretion called exudates including:

a. Type of soil,
b. Soil nutrient condition
c. Plant species and
d. Stage of plant development.

The understanding of the rhizosphere as a critical interface for soil and plants has encourage major researches in this area, leading to new technological development to face challenges of rapid population growth, food security and climate change. Microbial community structure in soils, in particular rhizosphere soil, is considered of great importance to assess soil quality to achieve high crop yields.

Biodegradation by microbes is the most common process of removal of hydrocarbons in soils. The degree of biodegradation of aliphatic hydrocarbons is typically lower than their aromatic counterparts. Aromatic and aliphatic hydrocarbons are organic contaminants with structural difference, but both classes of contaminants are subject to physicochemical processes, and when subjected to physicochemical processes they can affect the degree of loss, sequestration and interaction with soil micro flora. To ensure optimal biological performance in soil contaminant interaction, it is important to manipulate the degrading microbial populations and the environment using factors that control their interaction. This includes the use of hydrocarbon physico-chemistry, environmental conditions, bioavailability and the presence of catabolically active microbes. Environmental modification involves the manipulation of the physicochemical nature of the contaminated soil by altering pH, O_2, H_2O, and nutrient levels. Application of inorganic fertilisers is considered the most widely used amendment to successfully optimize C: P: S ratio in soils. The optimisation of the C: N: P ratio is considered to be one of the most important amendments enhancing the rate and extent of biodegradation. The practice of bioaugmentation is part of the interaction technology in soils used to remove target contaminant molecules. The operation involves the addition of enriched degrading microbial inoculums to remove target contaminant molecules. However, there is not yet a widely spread success of application of commercially available microbes.

SELF-ASSESSMENT EXERCISE

What are the importance of interaction between rhizosphere plant and microorganisms to agriculture?

4.0 CONCLUSION

Knowledge of the rhizosphere as a critical interface for soil and plants has contributed to new technological development addressing challenges faced by rapid population growth, food security and climate change. Interaction between rhizosphere plant and microbes has served in the optimisation of C: N: P ratio which is considered to be one of the most important amendments enhancing the rate and extent of biodegradation. Microbial biodegradation process has served in removal of hydrocarbons in soils.

5.0 SUMMARY

From this unit, you have learnt that:

- The communities of microbes can influence nutrient availability through process of solubilisation, chelation, and oxidation/reduction.
- Recent techniques developed to study microbial communities are based on new molecular, enzymatic, and organism-based techniques. The methods of studying microbial communities are grouped based on their ability to identify microbial biomass, diversity or activity.
- Interaction between rhizosphere plant and microbes has contributed to new technological development addressing challenges faced by rapid population growth, food security and climate change.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the nature and importance of microbial communities to people involve in crop production.
2. Enumerate benefits of interaction between rhizosphere plant and microorganisms to agriculture.
3. Discuss the nature of interaction between rhizosphere plant and microorganisms.

7.0 REFERENCES/FURTHER READING

Environmental Agency. (2006). *The Development and Use of Soil Quality Indicators for Assessing the Role of Soil in Environmental Interactions. Science Report SC030265 241pp.* www.environmental-agency.gov.uk

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MODULE 4 EFFECTS OF FERTILISERS ON SOIL-WATER ECOSYSTEM

UNIT 1 COMPONENT AND IMPORTANCE OF MINERAL FERTILISERS

CONTENTS

1.0 INTRODUCTION

Mineral fertilisers are materials containing essential nutrients for normal growth and development of plants. Mineral fertilisers provide mostly macronutrients such as nitrogen, phosphorus and potassium and may contain secondary macronutrients (sulphur, calcium and magnesium) when deficient in soil.

Fertilisers are usually applied because of their importance in crop growth and health, and their role in processes such as energy transfer, reproduction, maintenance of internal pressure and enzymatic actions. Mineral fertilisers are essential in increasing crop yield to meet the challenges of the increasing demand raised by the rapidly growing world population and food security.

2.0 OBJECTIVES

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

- define fertiliser
- identify types of fertilisers based on their components
- state benefits of fertiliser application.

3.0 MAIN CONTENTS

3.1 Definition of Fertiliser

Mineral fertilisers are either natural or manufactured materials, containing essential nutrients applied for normal growth and development of plants. Plant nutrients are food for plants some of which are used directly for human food, others to feed animals, supply natural fibres or produce timber. Man and all animals depend entirely on plants to live and reproduce. The public perception of mineral fertilisers often takes no account of these simple facts.

3.2 Component of Fertilisers

There are three major (macro) nutrients usually applied in large quantities, nitrogen, phosphorus and potassium. Other also required in substantial amounts are considered as secondary macronutrients include sulphur, calcium and magnesium. Micronutrients are usually required in small quantity and include boron, copper, iron, manganese, molybdenum and zinc.

Fertilisers are processed and package in 50kg fertiliser bags as single nutrient fertilisers e.g. Single Super Phosphate (SSP), Triple Super Phosphate (TSP) and Urea. When fertiliser contains more nutrients, it is referred to as multi-nutrient fertilisers. Some examples of multi nutrient (compound) fertilisers are Calcium ammonium nitrate (CAN), Diammonium phosphate (DAP), and Nitrogen Phosphorus and Potassium (NPK) in different grade such as 15:15:15, 20:10:10 and 27:13:13.

SELF-ASSESSMENT EXERCISE

Explain the component of fertiliser.

3.3 Importance of Fertilisers

Fertilisers are applied to soils or directly on plant leaves (foliar application) because of their benefits to crop growth and health. These nutrients are constituents of many plant components such as proteins, chlorophyll and nucleic acids. They are essential for processes such as

energy transfer, reproduction, maintenance of internal pressure and enzyme action. Micronutrients are elements helpful in maintain plant health and often present at the active sites of enzymes that carry out the plant's metabolism.

Mineral fertilisers are usually applied to soil for increasing crop yields. Inorganic fertilisers application results in accumulation of soil organic matter and increase biological activity due to increased plant biomass production and organic matter returns to soil in the form of decaying roots, litter and crop residues.

4.0 CONCLUSION

Mineral fertilisers are natural or processed materials containing essential nutrients for normal growth and development of plants. Processed fertilisers are packaged as either single or multiple fertilisers. They play vital roles in crop growth and health, as well as in processes such as energy transfer, enzymatic actions and reproduction.

5.0 SUMMARY

From this unit, you have learnt that:

- Fertilisers are materials containing essential nutrients for normal growth and development of plants.
- Fertiliser may be packaged as either single or multi-nutrient in 50kg fertiliser bags.
- Fertilisers are applied to soil for their enormous benefit to crop growth and development.

6.0 TUTOR-MARKED ASSIGNMENT

1. What do you understand by the term fertiliser?
2. List four (4) benefits derive from the application of fertilisers.
3. Visit fertiliser shop or market close to you and identify two single nutrients and three multi-nutrient fertilisers common in the market for farmers use.

7.0 REFERENCES/FURTHER READING

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UNIT 2 EFFECT OF FERTILISER ON SOIL PROPERTIES AND SOIL ORGANISMS

CONTENTS

1.0 INTRODUCTION

The continuous use of mineral fertiliser to increase crop yield for the world increasing population have effect on soil physical and chemical properties as well as soil organisms. The effect may either be positive or negative, and requires careful and appropriate application of the required amount that will not accumulate and cause toxicity and deleterious effect on the soil ecosystem.

2.0 OBJECTIVES

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

- explain effect of fertiliser on physical properties of soil
- state clearly effect of fertiliser on chemical properties of soil
- explain the effect of fertiliser on biological component of soil.

3.0 MAIN CONTENT

3.1 Effect of Fertiliser on Soil Physical Properties

The application of inorganic fertilisers affect soil physical properties directly or indirectly such as aggregate stability, water holding capacity, porosity, infiltration rate, hydraulic conductivity and bulk density through facilitating decomposition of crop and animal residues into soil organic matter. The soil organic matter lowers soil bulk density, resulting in increased total porosity and water infiltration rate. Soil organic matter also increase aggregate stability by binding mineral particles and reduce their susceptibility to erosion processes. The application of mineral fertiliser also reduces soil erosion as the better developed canopy and extensive root system of fertilised crop protects the soil against erosion either by wind or water.

SELF-ASSESSMENT EXERCISE

Discuss how fertiliser application affects soil physical properties positively.

3.2 Effect of Fertiliser on Soil Chemical Properties

Soil acidification is a global problem and is of special significance in the humid tropics, as severe weathering and leaching have made a large percentage of tropical soils very acidic. The pH value of good agricultural land requires having soil pH range between 5.5 and 7.5. In the tropics, pH values are typically below 5.5, with pH values around 4.2 common. Low pH values mean acid soils: they reduce the nutrient availability and intake by plants; phosphorus in particular is fixed in the soil. The challenge therefore lies in using mineral fertilisers in such a way that they are harmless to the soil environment and allows nutrients to remain within the system. Over application of urea and nitrate nutrient fertilisers for cereal and pasture crops may result in acid build up. There is a discouragement on the use of ammonium sulphate nutrient carrying fertilisers, as it causes accumulation of sulphuric acid in soils thereby reducing pH and affecting some nutrient availability e.g. phosphorus (P). Therefore, there is need to understand soil nutrient retention status and crop requirement to avoid excessive fertiliser application in soils.

Association of fluoride, cadmium and some heavy metals in phosphorus fertilisers has resulted in toxicity of such heavy metals with resultant effect on death of soil microbes and breakdown in food digestion. The use of steel industry wastes as zinc fertiliser material has incorporated toxic metals such as arsenic, cadmium, chromium, lead and nickel into soils.

SELF-ASSESSMENT EXERCISE

Explain the challenges associated with fertiliser application on soil chemical properties.

3.3 Effect of Fertiliser on Soil Organisms

Continuous annual application of fertiliser to soil can change the soil microbial community directly or indirectly since they change the soil physical, chemical and biological properties. Some studies have documented that fertilisation has had significant impacts on the population, composition and function of soil microorganisms, and inorganic fertilisers have increased the soil microorganisms' activity (Dong et al., 2014). Long-term fertiliser application with mineral fertiliser promotes growth of bacteria, actinomycete and total microbial

organisms. High levels of fertiliser may cause breakdown of symbiotic relationships between plant roots and mycorrhizal fungi. The application of mineral fertiliser is found to be less effective than manure, therefore for effectiveness mineral fertilisation will require organic manure as supplement.

4.0 CONCLUSION

Mineral fertilisers have improved soil physical properties such as bulk density, aggregate stability, and water holding capacity and porosity, as well as retard process of soil erosion. However, many fertilisers have contributed to soil acidification especially in the tropical environment. Repeated fertilisation has significantly impacted population, composition and functions of soil microorganisms, and may be improved when supplemented with organic matter.

5.0 SUMMARY

From this unit, you have learnt that:

- Mineral fertiliser application has significant positive effects on physical properties of soil such as porosity, bulk density and moisture retention.
- Fertiliser application tends to increase soil acidity and requires appropriate application with caution.
- Repeated fertiliser application has significant impact on soil microbial community.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the effects of fertiliser on the following:

- Physical properties of soil.
- Chemical properties of soil.
- Biological properties of soil.

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UNIT 3 EFFECT OF FERTILISER ON WATER AND ATMOSPHERIC ENVIRONMENT

CONTENTS

1.0 INTRODUCTION

When fertiliser is applied in excess quantity than the amount a soil can retain for crop use, the remaining is loss through leaching, surface runoff and volatilisation. This lost amount may accumulate in water and cause eutrophication hazard. Therefore your knowledge of the effect of fertiliser on water and atmospheric environment may promote sustainable use of fertiliser.

2.0 OBJECTIVES

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

- explain effect of fertiliser on water environment
- explain effect of fertiliser on atmospheric environment.

3.0 MAIN CONTENT

3.1 Water Environment

Degraded soils (low cation exchange capacity) can only retain low amount of fertiliser, therefore high fertiliser application in such soils result in fertiliser loss through leaching, volatilisation and erosion. Nutrient transported through erosion process contaminates surface water in streams and rivers (example; NO_3 and P contamination from applied fertiliser). Leached nutrient pollutes ground water. This increase water acidity and eutrophication (Oxygen depletion and destruction of organisms in water). The main concern for P loss to surface and ground water is eutrophication of surface water. Eutrophication results in a decline in water quality characterised by increasing growth of algae, followed by depleted oxygen concentrations, sedimentation, death of fish and release of algal toxins. The P responsible for eutrophication originates from a variety of sources, not only from livestock production and other agricultural activities, but also from natural ecosystems and

direct discharge of human and industrial wastewater. Eutrophication occurs at very low concentrations of P in water.

Run-off water from crop field carries along surface applied fertiliser (phosphorus). This is considered as a major contributor to eutrophication of fresh water bodies. Fertiliser runoff rich in nitrogen compounds cause serious oxygen depletion in many parts of rivers, lakes, coastal areas and oceans. Cereal crops consume high amount of nitrogen. Therefore, high application of nitrogen-containing fertilisers leads to increased surface runoff and leaching into groundwater, resulting in groundwater pollution.

SELF-ASSESSMENT EXERCISE

Explain the effect fertiliser application has on water environment.

3.2 Atmospheric Environment

Volatilisation process causes loss of nitrogen, phosphorus and sulphur to the atmosphere. Loss of fertiliser gases occur if liquid fertiliser is applied on soil surface. The loss of H_2S gas in poorly ventilated environments is extremely poisonous and fatal. Industrial manufacturing of nitrogen fertilisers involve emission of greenhouse gases nitrous oxide, methane and carbon dioxides. These gases contribute to the atmospheric components influencing depletion of ozone layer, thus contributing to global warming and climate change.

4.0 CONCLUSION

Large amount of fertiliser application to facilitate crop growth has resulted in leaching and erosion into surface water, streams and rivers causing contamination problems. Volatilisation of fertilisers such as nitrogen, phosphorus and sulphur into the atmosphere has contributed to depletion of ozone layer, global warming and climate change.

5.0 SUMMARY

From this unit, you have learnt that:

- Applied fertiliser may be loss through leaching and surface run-off, and can cause pollution and eutrophication.
- Fertilisers lost into the atmosphere have contributed to depletion of ozone layer, global warming and climate change.

6.0 TUTOR-MARKED ASSIGNMENT

Explain how fertilisers applied into soils can affect water and atmospheric environment.

7.0 REFERENCES/FURTHER READING

IFA & UNEP. (2000). *Fertiliser Use and the Environment.* International Fertiliser Industry Association and United Nation Environmental Programme. Revised edition. Paris, 51pp. http://www.uneptie.org/2000_ifa_unep_use.pdf

UNIT 4 LONG AND SHORT TERM EFFECT OF FERTILISERS

CONTENTS

1.0 INTRODUCTION

Anthropogenic activities such as mineral fertilisers' application are done purposely for crop production. However, it may have short and long term effects on soil properties such as decrease in pH and accumulation of organic matter, as well as influence microbial communities.

2.0 OBJECTIVES

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

- explain short term effect of fertilisers
- state clearly long term effect of fertilisers

3.0 MAIN CONTENT

3.1 Short Term Effect of Fertilisers

In short term, the effects of fertiliser application are mostly considered to be beneficial in boosting crop production to meet the food requirement of the growing population. Soil microbes are sensitive to change in environment. Therefore mineral fertiliser application usually stimulates microbial growth, altered the structure of soil microbial community and increased enzyme activity relative to inorganic fertilisation.

3.2 Long Term Effect of Fertilisers

For several decades, intensive agriculture relied on non-renewable resources, especially on the fertility of the soil. For instance, the production of nitrogen fertiliser uses a lot of energy and nitrogen fertiliser releases nitrous oxide – a gas that is extremely more detrimental to the climate than carbon dioxide. Soils tend to increase acidity (decrease pH) after intensive addition of ammonium-based N

fertilisers. This has resulted in the discouraged use and manufacturing of ammonium sulphate (double acid) fertiliser in Nigeria.

The soils in many industrialised countries after long period of cultivation have excess nutrients. For example Western Europe has large quantity of nitrogen, potassium, and especially phosphorus. Excessive accumulation of phosphorus is due to its immobile nature and easily fixed within the soil environment. In Sub-Sahara Africa (small scale farmers), reverse is the case as nutrient deficiencies occur and is caused by intensive cropping that is associated with a complete lack or minimal use of fertilisers over decades. Applying high rates of nitrogen alone destroys the balance between the three macronutrients, N, P and K. This approach not only puts nitrogen to poor use; it also leads to increased humus depletion, rising soil acidification and, overall, a reduction in the nutrients available to the crops. Continuous use of NPK fertiliser also results in deficiency of micronutrients and is attributed to an imbalance in the nutrient ratios.

Most of phosphate fertilisers contain varying amounts of cadmium (Cd) and other heavy metals as contaminants from phosphate rock. Long term use of phosphorus fertilisers containing cadmium have resulted in their accumulation and other micronutrients causing soil contamination.

Other long term cumulative effect of continuous use of mineral fertilisers include a dramatic loss in biodiversity, soil erosion, soil salinisation and the loss of soil fertility. Nitrates pollute drinking water and over-fertilise lakes, causing algal blooms and killing fish.

SELF-ASSESSMENT EXERCISE

What are the effects of continuous fertiliser application on the environment?

4.0 CONCLUSION

The reliance on fertiliser for intensive agriculture has boosted crop production in meeting food challenges of the world growing population under short term basis. However, continuous use of fertiliser such as NPK results in deficiency of micronutrients and is attributed to an imbalance in the nutrient ratios. Repeated fertiliser application is regarded to contribute to increase soil acid especially in the tropics.

5.0 SUMMARY

From this unit, you have learnt that:

- Short term beneficial increase in crop yield as a result of fertilisation.

- Long term effect of mineral fertilisers application includes pollution of water, acidification, nutrient imbalance, soil erosion, loss of soil fertility and biodiversity.

6.0 TUTOR-MARKED ASSIGNMENT

Differentiate between short and long term effects of mineral fertiliser application.

7.0 REFERENCES/FURTHER READING

Bar, B.S., Singh, J., Singh, G & G. Kaur. (2015). "Effects of Long Term Application of Inorganic and Organic Fertilisers on Soil Organic Carbon and Physical Properties in Maize–Wheat Rotation". *Agronomy* 5: 220-238. www.mdpi.com/journal/agronomy.pdf.

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MODULE 5 EFFECTS OF PESTICIDES ON THE SOIL-WATER ECOSYSTEM

UNIT 1 FATE OF PESTICIDES

CONTENTS

1.0 INTRODUCTION

Pesticides are group of chemicals intentionally applied to the environment to suppress pests of plant and animal and to protect agricultural and industrial products. However, most of pesticides are not specifically targeting the pest only and during their application they also affect non-target plants and animals.

The use of pesticides to control pests such as insects, rodents, bacteria, fungi and nematodes have contributed significantly to successful agricultural practices. However, their use has left with it several impacts on the environments.

2.0 OBJECTIVES

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

- define pesticide
- explain clearly the entry and fate of pesticides in soils.

3.0 MAIN CONTENT

3.1 Definition Pesticides

Pesticides are chemicals applied to the environment in other to destroy pests and disease vectors of crops and animals. Pesticides application is to control pests such as insects, rodents, bacteria, fungi and nematodes. The chemicals are purposely applied to increase crop yields and improve public health.

3.2 Pesticides Entry to Soils

Pesticides enter the soil via spray drift during foliage treatment, wash-off from treated foliage, release from granulates or from treated seeds in soil. Some pesticides such as soil fumigants and nematocides are applied directly into soil to control pests and plant diseases present in soil.

The transport, persistence or degradation of pesticides in soil depends on their chemical properties as well as physical, chemical and biological properties of the soil. All these factors affect sorption/ desorption, volatilisation, degradation, uptake by plants, run-off, and leaching of pesticides. Pesticides applied to the environment have shown to have long term residual effects while others have shown to have fatal effects when not properly handled. Many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water, and contaminate wide environment. Organo-chlorine is a good persistent pesticide that can vary from few hours to many years in soil. Continuous pesticide application results in destructive effects in the environment that cannot be ignored.

SELF-ASSESSMENT EXERCISE

Explain the how pesticides get into soil environment.

4.0 CONCLUSION

Pesticides are chemicals intentionally applied to the environment to suppress pests of plant and animal and to protect agricultural and industrial products. The fate and distribution of pesticides depend on pesticides chemical properties as well as soil physical, chemical and biological properties.

5.0 SUMMARY

From this unit, you have learnt that:

- Pesticides are chemicals applied to the environment in other to destroy pests.

- The state of pesticides in soil depends on several factors that influence their sorption/ desorption, volatilisation, degradation, uptake by plants, leaching and run-off.
- Many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water, and contaminate wide environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define the term pesticide.
2. Explain the mode of entry and fate of pesticides in soils.

7.0 REFERENCES/FURTHER READING

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UNIT 2 EFFECTS OF PESTICIDES ON SOILS AND WATER ECOSYSTEMS

CONTENTS

1.0 INTRODUCTION

Agro-chemicals have a very important role in agricultural production. To reduce damage to crops, many kinds of pesticides are applied against rodents, insects and diseases to control their effect across the world.
Continuous application of pesticides leads to loss of biodiversity. This is because many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water, and contaminate wide environment. Depending on their chemical properties they can enter organisms, bio accumulate in food chains and consequently influence the health human beings. In general, intensive pesticide application results in several negative effects in the environment that cannot be ignored.

2.0 OBJECTIVES

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

- effect of pesticide soil properties
- effect of pesticide in water.

3.0 MAIN CONTENT

3.1 Effect of Pesticide on Soil Properties

Many of the chemicals used in pesticides persist in soils as contaminants, and their presence may adversely affect soil conservation. Not using the chemicals may reduce destruction of biodiversity and improve soil quality as more organic matter in the soil allows higher water retention.

An organic matter transformation by microbes is a key process in detoxification of pesticides in soils and contributes to nutrient cycling. Trace elements have been added to land in pesticides. However with continuous application heavy metal such as lead and arsenic can result in toxicity in soils.

3.2 Effect of Pesticide in Water

Pesticides applied to soils may be carried by surface runoff into nearby bodies of surface water or may percolate to groundwater. Organo-chlorine pesticides have shown persistence in soil and the resultant effect is contamination of surface and ground water. Pesticides may have their way into water through drifting during pesticide spraying by runoff from treated location. Sometimes pesticides are applied directly unto water surface for the control of mosquitoes. The contamination of water by pesticides depends on nature of pesticides, soil properties, weather conditions, landscape and also on the distance from an application site to a water source. Heavy rainfall shortly after application of pesticides to wet soil causes rapid transportation to groundwater. Streams and rivers are areas that frequently have more pollution than groundwater. Contamination of water is even more near the areas with substantial agricultural land use.

Once pesticides enter water bodies they have a potential to cause harmful effects on human health, aquatic organisms and can cause disruptions of the aquatic ecosystems. This may result into a loss in fish production in streams and large water bodies. The processes underlying pesticide retention in the soil reduce their mobility and thus, at least temporarily, diminish their transfer to water.

SELF-ASSESSMENT EXERCISE

Explain effect of pesticides in water environment.

4.0 CONCLUSION

Pesticides persist in soils as contaminants, and their presence may adversely affect soil conservation as pesticides destroy soil living organisms that improve soil quality.

5.0 SUMMARY

From this unit, you have learnt that:

- The transformations of organic matter by microbes have contributed to detoxification of pesticides in soils.
- Persistence of pesticides in soil results in contamination of surface and ground water.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the effect of pesticides on soil properties.
2. Explain the effect of pesticides on water.

7.0 REFERENCES/FURTHER READING

Aubertot, J.N., J.M. Barbier, A. Carpentier, J.J. Gril, L. Guichard, P. Lucas, S. Savary, I. Savini, & M. Voltz. (2005). *Pesticides, Agriculture and the Environment. Reducing the Use of Pesticides and Limiting their Environmental Impact.* Scientific Experimental Reports. INRA and Cemagref, France. 64pp.

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UNIT 3 EFFECTS OF PESTICIDES ON ORGANISMS

CONTENTS

1.0 INTRODUCTION

Pesticide persistence in soils has both negative and positive impact on living organisms depending on the pesticide and the organism. The effect of pesticide is not only in soil organisms but when it is transported to water bodies or volatilises into the atmospheric environment may affect other non-target organisms such as birds, bees, butterfly and fish. The response of soil micro-organisms in metabolising and degrading pesticide is important in biotechnology.

2.0 OBJECTIVES

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

- explain the effect of pesticide on soil microorganisms
- explain the effect of pesticide on invertebrates
- explain how pesticides affect birds and bees
- state the effect of pesticides on fish and other aquatic organisms.

3.0 MAIN CONTENT

3.1 Effect of Pesticide on Soil Microorganisms

Some pesticides stimulate the growth of microorganisms, but other pesticides have depressive effects or no effects on microorganisms. For examples, carbofuran stimulated the population of Azospirillum and other anaerobic nitrogen fixers in flooded condition, but butachlor reduced the population of Azospirillum and aerobic nitrogen fixers in non-flooded soil. Diuron and chlorotoluron showed no difference between treated and non-treated soils, and linuron showed a strong difference. Insecticide containing phosphorus such as methamidophos

stimulated soil microbial growth, but other P-containing insecticide fenamiphos was detrimental to nitrification bacteria.

Soil microorganisms are able to metabolise and degrade a lot of pollutants and pesticides, therefore are of great importance in biotechnology use. On the other hand, microbial degradation can lead to formation of more toxic and persistent metabolites in soil. Although soil microbial population are characterised by fast flexibility and adaptability to changed environmental condition, the application of pesticides (especially long-term) can cause significant irreversible changes in their population.

3.2 Effect of Pesticide on Invertebrates

Soil invertebrates like earthworms, spiders, insects, nematodes, mites and other micro-arthropods make up the soil food web and enable decomposition of organic materials such as plant residues and manure. Soil organisms enhance soil aggregation and porosity, and thus increasing infiltration and reducing runoff, thus reducing soil loss through erosion. Therefore pesticide effect on these invertebrates has impact on soil properties.

Earthworms are use as bio-indicator of soil contamination as they are providing an early warning of decline in soil quality. They serve as model organisms in toxicity testing. Earthworms are characterised by high ability to cumulate a lot of pollutants from soil in their tissues, thus they are used for studying of bioaccumulation potential of chemicals. Frequent use of pesticide reduces growth and reproduction of earthworm and may lead to their eventual death. Other soil species are also often affected by pesticides application and restructuring non-target soil community.

3.3 Effect of Pesticide on Birds and Bees

Pesticides have had some of their most striking effects on birds, particularly those in the higher trophic levels of food chains, such as bald eagles, hawks, and owls. These birds are often rare, endangered, and susceptible to pesticide residues such as those occurring from the bio-concentration of organochlorine insecticides through terrestrial food chains. Pesticides may kill grain- and plant-feeding birds, ducks and geese. Populations of insect-eating birds such as partridges, grouse, and pheasants have decreased due to the loss of their insect food in agricultural fields through the use of insecticides.

Bees are very good in pollination of crops. Since they are important in pollination of crops, pesticides effect in destroying bees will reducing crop yield. This will have effect on the economy as well as on the ecological system. Pesticides effect on bees is closely watched because

of their impact in crop pollination. Areas of intensive agriculture with high pesticide loads result in decline in wild bees, bumblebees and butterflies population.

SELF-ASSESSMENT EXERCISE

Explain how the effect of pesticides on non-target organisms can crop production and man.

3.4 Effect of Pesticide on Fish and other Aquatic Organisms

Major pesticide contamination of water bodies has been through widespread mortality of fish and marine invertebrates. This has resulted from pesticides application on agricultural land and from the discharge of industrial effluents containing pesticides into waterways.

Pesticides applied on soil at recommended levels rarely had any detrimental effect on microbial populations or their activities. Their effect is more on invertebrate populations, as pesticides induce rapid increase in population of individual species of floodwater zooplankton and reducing populations of aquatic oligochaetes.

4.0 CONCLUSION

Pesticides are applied purposely to destroy pests; however their effect has been on wide range of non-target organisms. Pesticides have destroyed insects that served in food chain system causing bird's death and migration. Pesticides have caused widespread mortality of aquatic organisms. The positive effect of pesticide is that some stimulate the growth of microorganisms in soil.

5.0 SUMMARY

From this unit, you have learnt that:

- Some pesticides stimulate the growth of microorganisms, but other pesticides have depressive effects or no effects on microorganisms.
- Pesticide's application affects soil invertebrate growth and population resulting in the restructuring of non-target soil community.
- Effect of pesticides on birds has been through destroying insect that served in the food chain system causing birds' death and migration.
- Pesticides contaminate water bodies causing widespread mortality of fish and marine invertebrates.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the effect of pesticide on soil microorganisms.
2. Explain how pesticide application affects soil invertebrates.
3. Pesticide is applied to destroy pest, how does it affect birds and bees?

7.0 REFERENCES/FURTHER READING

Aubertot, J.N., J.M. Barbier, A. Carpentier, J.J. Gril, L. Guichard, P. Lucas, S. Savary, I. Savini, & M. Voltz. (2005). *Pesticides, Agriculture and the Environment. Reducing the Use of Pesticides and Limiting their Environmental Impact.* Scientific Experimental Reports. INRA and Cemagref, France. 64pp.

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UNIT 4 EFFECTS OF HERBICIDES ON SOIL

CONTENTS

1.0 INTRODUCTION

Traditional farming involves the use of hoe to remove weeds and was less efficient. Today, modern agriculture relies heavily on herbicides for the control of weeds in crop production to maximise yields. The environmental fate of herbicides is a matter of recent concern given that only a small fraction of the chemicals reach the weeds, leading to potential impacts of residual herbicides on physical, chemical and biological properties of soil. While herbicides are very important to agriculture, under certain circumstances they may act as pollutants that can deteriorate soils, groundwater and surface water.

2.0 OBJECTIVES

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

- state how herbicides enter soils
- explain the effect of herbicides on physical and chemical properties of soils
- explain how herbicides affect soil living organisms.

3.0 MAIN CONTENT

3.1 Herbicides Mode of Entry into Soils

Herbicides are applied to destroy weeds and therefore their application onto soil is not intentional. Herbicides can enter soil environment from direct interception of spray by the soil surface during early season, runoff of the herbicide from vegetation and leaching from dead plant material. The herbicide concentration may vary from a few μg to mg per kg soil, as most of the applied chemical is retained within the top 5 cm of soil.

Herbicide adsorption to soil determines their persistence and mobility throughout the soil ecosystem. The processes related to sorption are dependent on several factors related to soil characteristics such as mineral composition, organic matter content, soil solution chemistry, and chemical characteristics of the herbicide.

3.2 Herbicide Effect on Physical and Chemical Properties

Herbicides applications to destroy weeds reduce vegetative cover of the soil surface, thus promoting soil erosion. Erosion destroys soil structure creating imbalance in soil fertility. A bare land with poor soil structure and poor soil fertility cannot support the growth of plants and other forms of life in it hence may result in the destruction of the particular ecosystem.

Soils treated with pre-emergence herbicide becomes bare and are more exposed to moisture loss through evaporation, whereas, those treated with post-emergence herbicide conserve moisture as the dead weeds serve as mulch material. Similarly lawn mower are better alternative to the hand and hoe weeding as the destroyed weeds cover soil surface protecting the land from evaporation of moisture and erosion.

Herbicides may react with soil minerals to form chelates thereby reducing the availability of metallic elements for uptake by plants. Formation of chelates reduces heavy metals pollution in soil solution that could have been leached into groundwater. Excessive applications of herbicides on our farmland beyond the recommended rates with the intention of destroying weeds cause pollution of groundwater either by rain washing or leaching as excess amount may not be adsorb by soil.

SELF-ASSESSMENT EXERCISE

Explain the effect of herbicides on physical and chemical properties of soils.

3.3 Herbicide Effect on Biological Properties

Adsorption of herbicide by soil renders it temporarily inactive, which prevents harmful effects on soil biota but also makes them less bioavailable for microbial degradation because most microbes may not be able to utilize herbicides in the adsorbed state. Herbicide application destroys Azotobacter, thus reducing nitrogen-fixation in soils. Whereas, herbicide increases fungi in soils, indicating that these microorganism use herbicides as sources of biogenous elements. Differential toxicity of herbicides to soil microorganisms may alter community structure, including potential increases in plant or animal pathogens. Herbicides may also cause changes in microbial community function and concomitant impacts on soil health and ecosystem processes. However,

when herbicides accumulate with continuous application on our farmland, it can reach toxic levels in the soil and become harmful to microorganisms, plants, wildlife and man. Glyphosate is a non-selective herbicide that is mostly in use worldwide, but reduces earthworm population as this herbicide reduces their feeding activity and viability. Herbicides also can affect predatory arthropod community such as spider and beetle in agricultural field. This may influence biological control in agro-ecosystems.

4.0 CONCLUSION

Herbicides have efficient control of weeds and increased crop yield, the application of herbicides have both beneficial and harmful impact on the soil environment. Herbicide adsorption of heavy metals controls pollution is beneficial, whereas the harmful effects include promoting erosion and destruction of Azotobacter bacteria that fixe nitrogen in soils.

5.0 SUMMARY

From this unit, you have learnt that:

- Herbicides are applied to destroy weeds and not intentional to affect soils.
- Herbicide exposes the soil to direct rain resulting to soil erosion and alteration of soil structure.
- Herbicides react with heavy metals to form chelates thereby reducing their effect as soil pollutants.
- Herbicides change microbial community function and affect soil health.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain how herbicides enter soil environment.
2. Herbicides are useful in controlling weeds, however their effect on soil physical and chemical properties can be observed. Briefly discuss this statement.
3. Explain how herbicides affect living organisms in soils.

7.0 REFERENCES/FURTHER READING

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MODULE 6 EFFECTS OF ACID RAIN ON THE SOIL-WATER ECOSYSTEM

UNIT 1 ACID RAIN

CONTENTS

1.0 INTRODUCTION

An important impact of anthropogenic activities on water quality that warrants continued attention is acid deposition, commonly called acid rain. Today, many lakes and streams have become too acidic to continue to support aquatic life as in the past because of the emission and deposition of gases associated with the burning of fossil fuels and volatilisation of nutrients.

Freshwater have been supportive to irrigated agriculture, fish and wildlife games, recreation, drinking needs, and industries. However, anthropogenic activities have degraded water over time, although there are some improvements observed lately as a result of pollution reduction measures in countries like United States (NYSERDA and EMEP, 2005). Therefore, with improved understanding of the impacts of anthropogenic activities on water, we will be better prepared to address this problem effectively, so that current and future generations can rely on the use of water as a vital resource.

2.0 OBJECTIVES

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

- state sources of acid in rain
- explain clearly how acid rain is formed
- list effects of acid rain on the environment.

3.0 MAIN CONTENT

3.1 Sources of Acid Rain

Acid rain is comprised of sulfuric acid, nitric acid and ammonium derived from sulfur dioxide (SO_2), nitrogen oxides, and ammonia (NH_3). These compounds are emitted by the burning of fossil fuels, industries, vehicles and by agricultural activities such as fertiliser application and dumping of animal wastes (urine and feaces). Acid deposition includes all forms in which the various acid compounds are precipitated from the atmosphere to the Earth such as clouds, rain, fog, snow and gases.

The major contributor of nitrogen oxide emissions is transportation, whereas ammonia emission is derived mainly from fertilised soil (urea fertiliser) and animal wastes especially urine and feaces. Electricity utilities account for high proportion of sulfur dioxide emissions in United State of America (NYSER and EMEP, 2005).

3.2 Formation of Acid Rain

Deposition of acid in rain is considered to be acid precipitation from the atmosphere to the Earth's surface. Acid forming compounds such as ammonia, nitrates, are also released by soil and plants, compounds from the soil and plants, and compounds from coal and petroleum industrial areas. These gases are emitted into the atmosphere and contribute to acid rain when it precipitates to the soil. The amount of nitrogen compound in rainfall is influenced by season and location. Great amount of acid rain occur in areas with high annual precipitation such as the tropics, industrial cities like Lagos and Port-Harcourt in Nigeria, and areas close to large animal (poultry) farms.

Natural rainwater has a pH of approximately 5.6. However, when natural rain is substantially augmented by inputs of strong acid such as fossil-fuel combustion, the pH of rain water may decrease to as low as 4.0 indicating increase in acidity. The precipitations of these acid substances acidify soil and surface water resulting in several changes in the environment.

SELF-ASSESSMENT EXERCISE

How is acid rain formed?

3.3 Effect of Acid Rain

The deposition of acid has changed soils and water environment through the following ways:

1) Provide nitrogen nutrient to soil in a readily available form for plant growth.

2) Acid deposition also results in elevated inputs of nitrogen in the form of nitric acid and nitrate.

3) Increase acidity of soils and water.

4) Acid deposition accelerated leaching of bases (Ca and Mg), thus increasing toxic metals such as aluminum and mercury in soils.

5) Increasing lakes and streams acidity with related negative impacts on water quality and aquatic life.

6) Acidification can lead to decrease in population of fish as they move to downstream areas.

4.0 CONCLUSION

Acid rain is a combination of natural rain and gases that precipitate together increasing acidity of rain water. These have caused several changes in the soil and water environment in the form of increasing acidity, leaching of basic nutrients and decreasing aquatic population.

5.0 SUMMARY

From this unit, you have learnt that:

- Acid rain is comprised of sulfuric acid, nitric acid and ammonium derived from emission of burning of fossil fuels, industries, vehicles and by agricultural activities.
- Acid rain is formed from the emitted gases which eventually precipitated along with rain.
- Acid deposition contributes nitrogen nutrient in available form, depleting Ca and Mg through leaching process.
- Increase in acidity reduces population of aquatic life.

6.0 TUTOR-MARKED ASSIGNMENT

1. Mention any two acid producing substances that may be present in acid rain.
2. Enumerate three anthropogenic activities contributing to acid rain in Nigeria.
3. Explain the process of formation of acid rain.
4. Clearly state four (4) effects of acid rain.

7.0 REFERENCES/FURTHER READING

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UNIT 2 OTHER WATER SOURCE (SURFACE AND GROUNDWATER)

CONTENTS

1.0 INTRODUCTION

Changes in soils impact surface and groundwater as the water rely on the precipitation from atmosphere or seepage from the surrounding soil. Water do not only contain acid (low pH), but may be saline (excess salt with high pH), and when use in irrigated agriculture affect crop production. This is because of its diverse effect on soil and plant. Therefore your understanding of water quality will help in sustainable use and management of the agricultural environment.

2.0 OBJECTIVES

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

- state how and where surface and groundwater can be obtained
- explain how salt build up in soil and water
- explain clearly the effect of both acidic and saline water on the environment
- state measures that can be taken to remedy salt affected soils.

3.0 MAIN CONTENT

3.1 Source of Surface and Groundwater

Surface and groundwater from wells, dams, shallow aquifers, boreholes, rivers and streams have been used for irrigation. These are supplied by rainfall and intrusion from surrounding water into the groundwater environment.

3.2 Effect of Surface and Groundwater

Many surface-water impacts are related to changes in soils that have been caused by long term deposition of acid. Acid deposition has altered soils across large areas by:

a) Water containing acid depletes calcium and magnesium reducing soil fertility.
b) Acidic water mobilise inorganic aluminum and iron when use in irrigating farm land
c) It increases accumulation of sulfur and nitrogen.
d) Water-logging causes saturation of root zone leading to oxygen deficiency.
e) Decreases in quality of water and aquatic life population.

3.3 Origin of Salt Build-up

Sodium salts that build up resulting in soil salinity originates from the earth's crust. The salt can result from weathering, in which small amounts of rock and other deposits are dissolved over time and carried away by water. This slow weathering may cause salts to accumulate in both surface and underground waters. The surface runoff of these dissolved salts is what gives the salt content to our oceans and lakes. Fertilisers and organic amendments also add salts to the soil.

The major source of salinity problems is usually irrigation water. This is a gradual process that results in salts accumulation over time. Salt problems occur when water remains near the surface and evaporates, and when salts are not dissolved and carried below the root zone.

Soils naturally high in soluble salts are usually found in arid or semi-arid regions, where salts often accumulate because there is not enough rainfall to dissolve and leach them out of the root zone. Salt spray near coastlines can also cause salts to build up in the soil. In areas with shallow water tables, water containing dissolved salts may move upward into the rooting zone. This occurs by capillary action. Salt buildup can result into three types of soils: saline, saline-sodic and sodic.

Saline soils

Saline soils contain enough soluble salts to injure plants. They are characteris0ed by white or light brown crusts on the surface. Saline soils usually have an EC of more than 4 mmol cm^{-1}. Salts generally found in saline soils include NaCl (table salt), $CaCl_2$, gypsum ($CaSO_4$), magnesium sulfate, potassium chloride and sodium sulfate. The pH of saline soils is generally below 8.5.

Sodic soils

Sodic soils are low in soluble salts but relatively high in exchangeable sodium. Sodic soils cause plant rooting problems. Soil is high pH with ranges from 8.5 to 12.0.

High sodium levels disrupt both the chemical and physical composition of soil clays. As a result, the soil surface has low permeability to air, rain and irrigation water. The soil is sticky when wet but forms hard clods and crusts upon drying. This phenomenon may not occur in very sandy soils because they lack clay content.

3.4 Effect of Salinity

When salts accumulate in soils, problems arise for two main reasons: the soil becomes less permeable, and the salt damages or kills the plants. The first problem is associated with the soil structure. In sodic soils, high levels of exchangeable sodium cause the individual sand, silt and clay particles to be separated and not clumped together into larger particles. This dispersion makes the soil tight and impervious, so that it allows little air, rain or irrigation water to permeate into the soil. Therefore, the plants may not receive enough moisture and oxygen to grow. Salts may accumulate on the soil surface because they cannot leach out of the root zone.

Plants can also be damaged by salt effects or toxicity. In saline and saline-sodic soils, high concentrations of soluble salts reduce the amount of available water for plants to use. High levels of sodium can be toxic to certain plants. If your soil has a high sodium salt content, the plants growing there will not be as vigorous as they would be in normal soils. Seeds will germinate poorly, if at all, and the plants will grow slowly or become stunted. If the salinity concentration is high enough, the plants will wilt and die, no matter how much you water them.

The very high pH in salt affected soils greatly changes nutrients available to the plants. These high pH levels change the ionic form of many plant nutrients to forms that make them unavailable to plants. As soils become more saline, plants become unable to draw as much water from the soil. This is because the plant roots contain varying concentrations of ions (salts) that create a natural flow of water from the soil into the plant roots. If the salinity concentration in the soil is high enough, the plant will wilt and die, regardless of the amount of water applied.

SELF-ASSESSMENT EXERCISE

How does salt build up and what are some of their effect to agriculture?

3.5 Correcting Salt-affected Soils

Salt-affected soils can be corrected by:

a) **Improving drainage:** Deep tillage can be used to break up soils with poor drainage as well as claypans and hardpans. The tilling helps water move downward through the soil and leach excess salt out of the crop root zone.

b) **Leaching is** used to reduce the salts in soils. The water must be relatively free of salts particularly sodium salts.

c) **Reducing evaporation:** The application of residue or mulch to soil can help lower evaporation rates.

d) **Chemical treatments:** Before leaching saline-sodic and sodic soils, you must first treat them with chemicals, to reduce the exchangeable sodium content. In general, gypsum is the safest and most effective material. The amount of amendment you need to correct saline-sodic and sodic soils is based on the amount of sodium in the soil. Several other factors also influence the amount applied: the leaching rate, the solubility and reaction rates of the amendments, and the conversion of free carbonates to gypsum.

4.0 CONCLUSION

Water may be acidic or saline depending on its source. Therefore water needs to be examined before use for domestic and irrigation purposes, and monitored to avoid acid or salt build-up that may deteriorate soil and water condition required for our agriculture.

5.0 SUMMARY

From this unit, you have learnt that:

- Apart from rain, water may be sourced from wells, dams, shallow aquifers, boreholes, rivers and streams for domestic and irrigation purposes.
- Acid water influences nutrient status of soil by depleting calcium and magnesium, accumulates nitrogen and sulphur, and mobilises aluminum and iron.
- Soil salinity originates from earth crust through weathering process and accumulates excess salts in surface and groundwater via intrusion.
- The major source of salinity problem is usually irrigation water.
- Salinity causes less water permeability and poor aeration, hence poor growth of plant.

- Salt affected soil may be remedied through improving drainage, leaching, reducing evaporation and chemical treatment of soils with gypsum.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss briefly the effect of water containing acid on the environment.
2. How does salt build up in water that may be used for irrigation or domestic purpose in your country?
3. Explain the effect of salinity to agricultural practices.
4. What are some of the measures you will take to address the problems of salt affected soils in Nigeria?

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MODULE 7 EFFECTS OF ORGANIC AMENDMENTS ON SOIL-WATER ECOSYSTEM

UNIT 1 SOIL ORGANIC MATTER AND SOIL LIVING ORGANISMS

CONTENTS

1.0 INTRODUCTION

Soil organic matter is carbon compounds of plant and animal residues undergoing decomposition process. Soil living organisms decompose the plant and animal residues and further mineralized them to release nutrients required for your plant growth. These soil living organisms differ in sizes and functions. Some of the soil organisms are involve in organic matter decomposition and bioremediation of polluted soils. Their functions are essential for the sustainable management of your environment.

2.0 OBJECTIVES

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

- state what is soil organic matter
- explain what are soil organisms.

3.0 MAIN CONTENT

3.1 Soil Organic Matter

Soil organic matter comprises wide range of carbon compounds in soil and includes plant and animal residues undergoing decomposition

process, as well as cells and tissues of soil organisms and substances synthesised by the soil living organisms. Soil organic matter is mostly obtained from the residue of harvested crops. Therefore, any practice that will improve crop yield will impact organic matter content in soils. The application of mineral fertilisers containing nitrogen boost biological (vegetative plant) yield of crop, thereby increasing the amount of residues returned to the soil. The slow decomposition of residue and rapid utilisation of carbon compounds result in only a small fraction left as soil organic matter.

3.2 Soil Organisms

Soil living organisms vary widely and contribute to diverse activities that are essential for the sustainable function of natural and managed ecosystems. The organisms are many and vary in sizes referred to as macro and microorganisms. Macro-organisms are those visible to the natural eyes, and include earthworm, termite and soil borne pests. Microorganisms are identified by the aid of microscope, and include bacteria, fungi and virus.

Soil organisms can be identified or grouped base on functions they perform in the ecosystem. They are the critical factors that determine nutrient cycling, soil degradation, soil organic matter decomposition and bioremediation of soil pollution. Certain bacteria in symbiotic association with legumes fixed nitrogen as nutrients for crop utilisation. Many soil organisms perform other functions like decomposition of dead animals and crop residues, transformation of elements, and others serve as soil-borne pests and diseases. Some are associated with the provision of goods and the regulation of ecosystem processes. These functions are essential for the sustainable management of environment.

SELF-ASSESSMENT EXERCISE

Briefly explain what you understand by soil living organisms.

4.0 CONCLUSION

Soil living organisms vary widely in size, from macro level to those that are microscopic in nature. They contribute in decomposition of organic matter which is essential in nutrient cycling, soil degradation and bioremediation of soil pollution. These diverse activities of soil organisms on organic matter help in the sustenance of natural and managed ecosystems.

5.0 SUMMARY

From this unit, you have learnt that:

- Soil organic matter is obtained from residues of plant and animals.
- Soil living organisms vary widely in size and their activities help in the sustenance of natural and managed ecosystems.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain what you understand by the term soil organic matter.
2. What are the difference between soil organic matter and soil living organisms?

7.0 REFERENCES/FURTHER READING

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UNIT 2 EFFECT OF ORGANIC AMENDMENTS ON SOIL PROPERTIES

CONTENTS

1.0 INTRODUCTION

Organic amendment is an excellent source of organic matter as well as nutrients. The application of crop residue, farm yard manure and other forms of manure to the soil directly adds organic matter. The various organic amendments play a variety of roles in soil nutrient, water and biological cycles. The application of organic amendments into soil system significantly contributes to the improvement of soil physical, chemical and biological properties. Organic amendments can indirectly increase soil organic matter because it increases crop yields and therefore contribute to the amount of residues returned to the soil. Therefore, increase in application of organic amendments into soil will contribute to sustaining the environment for anthropogenic activities especially agriculture.

2.0 OBJECTIVES

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

- state clearly beneficial effects of organic amendments on physical properties of soil
- state clearly effect of organic amendments on chemical properties of soil
- explain the effect of organic amendments on biological component of soil.

3.0 MAIN CONTENT

3.1 Effect of Organic Amendments on Physical Properties

Soil organic matter decreases in bulk density and reduce the compaction as the material is light compare to soil inorganic constituent. The presence of soil organic matter loosens particles resulting in improving

soil structure and aeration. The beneficial consequence of soil organic matter reducing bulk density and improving soil structure is that crop root penetrates soil system with ease and increase tuber size, thus increasing economic yield of crops. Animals boring of soil increase infiltration rate and reduce surface runoff of water that may cause erosion. Increase in infiltration rate also reduces soil loss from erosion. Addition of organic matter increase aggregate stability, hence reducing soil erosion. Increase in soil organic matter increases water retention capacity, thus providing adequate water for plant growth.

SELF-ASSESSMENT EXERCISE

What are the benefits farmers derive with regard to soil physical properties by applying organic amendment to soil?

3.2 Effect of Organic Amendments on Chemical Properties

Organic amendments applied to soils decompose and mineralised through the action of microbes to release organic carbon, nitrogen, phosphorus and sulphur, which are macronutrients required by plants for growth and development. Decomposed organic amendments serve in stabilising pH by adsorbing H^+ in response to the addition of acidic materials and releasing H^+ in response to addition of alkaline materials. Organic amendments contribute to the high cation exchange capacity (200 to 250 cmol(+)kg^{-1}) of soil organic matter, thus providing exchange site for adsorption of nutrient and releasing the nutrients when required by growing plants. Mineral soils are low in cation exchange capacity (CEC) with least CEC values ranging 2 and 5 cmol(+)kg^{-1} in sandy soils. The low CEC values in mineral soils compared to the high content in organic matter can be augmented in such soil through addition of suitable organic amendments into soil to improve soil nutrient retention for crop utilisation. The complex bond association between organic material and micronutrients retain micronutrients and provide them in readily available form when required by plants. For instance, micronutrients copper (Cu) and zinc (Zn) bond with organic compounds to form chelates thereby help to dissolve and mobilise these micronutrients. The contributions of organic matter in improving soil properties have generally increased soil productivity.

SELF-ASSESSMENT EXERCISE

Explain the contribution of organic amendment on soil chemical properties.

3.3 Effect of Organic Amendments on Biological Properties

Influence of organic amendment on improving soil structure and reducing bulk density contributes to increasing soil air use by microbes for respiration. It also allows easy movement of earthworm through the

soil, thus burrowing and adding more macro-pores. Organic amendment supply carbon-rich organic compounds to C-limited soils used in crop production. The addition of carbon-rich organic compounds provides food for the microbial biomass resulting in increase in the community and may change the composition of the microbial community. Changes occurring in microbial community are attributed to many bacteria surviving on easily available carbon compounds, while fungi seem to prefer more complex C compounds. Application of organic fertilisers can increase microbial activity in soils more than inorganic fertilisers.

4.0 CONCLUSION

The application of organic amendment significantly improves soil properties such as; decreasing bulk density, improving aggregate stability, water and nutrient retention. Organic amendments also retard process of soil erosion and serve as food to soil organisms. Hence organic amendment is vital to sustaining the environment for human activities.

5.0 SUMMARY

From this unit, you have learnt that:

- Organic amendments have beneficial effects on soil physical properties such as improving soil structure, porosity, and moisture retention, and decreasing bulk density.
- Organic amendments contribute to nutrient retention by significantly increasing cation exchange capacity of soil.
- The application of organic amendment supply carbon-rich organic compounds serving as food for enriching soil microbial community.

6.0 TUTOR-MARKED ASSIGNMENT

1. Anthropogenic activities contribute organic amendments to soils; discuss the benefits in forms of:

    - Physical properties of soil.
    - Chemical properties of soil.
    - Biological properties of soil.

7.0 REFERENCES/FURTHER READING

Agbede, O.O. (2009). *Understanding Soil and Plant Nutrition*. Petra Digital Press, Nigeria. 300pp.

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UNIT 3 SHORT AND LONG-TERM EFFECT OF ORGANIC AMENDMENTS ON SOIL-WATER ECOSYSTEM

CONTENTS

1.0 INTRODUCTION

Human activities contribute organic amendments continuously to the soil environment either as domestic wastes, crop residues or as farm yard manure. The effect of organic amendments in the environment can be assessed under short or long term.

2.0 OBJECTIVES

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

- explain short term effect of organic amendments
- state clearly long term effect of organic amendments.

3.0 MAIN CONTENT

3.1 Short Term Effect of Organic Amendments

Organic amendments may be applied to cropland to provide nutrient elements that include N, P, S, Ca, Mg, K and Na. The nutrient content of organic amendments from animal source is highly variable, depending on the livestock species. In areas of adequate rainfall and drainage, application of organic amendment at crop production required rates do not create a problem over short term, as the salts are leached through the soil profile. The utilisation of organic carbon rich compound by both plants and microbial biomass depletes soil carbon within short period of crop cultivation.

The concentration of many micronutrients in organic amendment is generally low. Therefore, short term risk of excessive accumulations of these micronutrient elements is generally small if organic amendment is applied at recommended rates and frequencies.

3.2 Long Term Effect of Organic Amendments

Anthropogenic activities have resulted in continuous and widespread of urban and industrial organic waste materials. The distribution of these organic waste released to soils by human activities is related to how and where they are added. For instance, the amount of organic contaminants in the soils of an industrially-contaminated site may vary depending on the activities conducted on the site. Therefore, strategies for recycling such organic waste in agriculture must be developed. Some of the long-term effects of application of these organic materials include:

a. The practice of regular application of organic amendments have improved aggregate stability and decreased bulk density of soils over long term period.

b. Processes in soils like release of nutrients, carbon sequestration and possible build-up of toxic elements do evolve slowly and take long period to manifest their effects. These effects are present only when repeated applications occurred.

c. The addition of organic matter from external source can lead to an improvement in soil biological functions, even more than a decade after spreading, depending on the quantity and quality of materials applied.

d. Long-lasting application of several organic amendments can enhance soil available potassium, extractable phosphorous and organic carbon. Soil organic carbon has shown increase of almost twice the amount in soils without fertilization. Long-term application of sewage sludge, compost and farmyard manure resulted in an increase in total C and N content of the soil.

e. Consistent application of the highest rates of compost has shown best performance of crop, and it is more efficient if the amendment is combined with mineral fertilisers. Furthermore, the residual effects in form of slow-release of nitrogen nutrient can contribute to increasing crop yield significantly with time, without polluting groundwater through leaching process.

f. Long periodic application of organic waste in soils result in chelates formation, thereby controlling negative impacts of heavy metals applied to soil.

g. Long-term application of organic amendment can play a positive role in climate change mitigation by reversing the process of soil degradation through soil carbon sequestration.

SELF-ASSESSMENT EXERCISE

List any five long term effects of organic amendments to agriculture and the environment.

4.0 CONCLUSION

Organic amendment significantly contributes on both short and long term basis on the environment. It contributes in providing nutrients such as organic carbon, N, P, S, Ca and Mg, and also low risk associated with the accumulations of micronutrient elements.

5.0 SUMMARY

From this unit, you have learnt that:

- Application of organic amendment is a key to providing nutrients such as organic carbon, N, P, S, Ca and Mg, with low risk of accumulations of micronutrient elements under short term period.
- Organic amendment distribution in soil by human activities is influenced by how and where they are added.
- The long term effect of organic amendments include improved aggregate stability, moisture retention, enhanced availability of K, P and organic C. Organic amendment forming chelates help in reducing negative impacts of heavy metals in soils.

6.0 TUTOR-MARKED ASSIGNMENT

Enumerate long term effects of organic amendments on the environment.

7.0 REFERENCES/FURTHER READING

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MODULE 8 ENVIRONMENTAL IMPACT ASSESSMENT

UNIT 1 ENVIRONMENTAL IMPACT ASSESSMENT

CONTENTS

1.0 INTRODUCTION

Environmental impact assessment is an important management tool for improving the long-term viability of projects. Its use can help to avoid mistakes that can be expensive and damaging in environmental, social and economic terms. This decision will determine if a project should move forward or not with its development. Environmental impact assessment is an information provision tool which provides information to the key decision makers that will determine whether a project should be given consent. This concept has made Environmental Impact Assessment to be one of the most adopted environmental tools by governments and development institutions globally. The decision made therefore helps to minimise environmental costs and consequently sustain the environment for the future.

2.0 OBJECTIVES

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

- define environmental impact assessment
- explain history of Environmental Impact Assessment
- list the objectives of Environmental Impact Assessment
- enumerate the functions of Environmental Impact Assessment.

3.0 MAIN CONTENT

3.1 Definition of Environmental Impact Assessment

i. Environmental impact assessment is a systematic process that examines the environmental consequences of development actions, in advance (Glasson *et al*., 2005).

ii. The Southern African Institute for Environmental Assessment (SAIEA) defines Environmental Impact Assessment as a process to identify, evaluate and assess the potential effects on the environment of a proposed development before a major decision or commitment is made (SAIEA 2005).

iii. Environmental Impact Assessment (EIA) can broadly be defined as a study of the effects of a proposed project, plan or program on the environment (Ogala, 2007).

iv. EIA is a tool for decision-makers to identify potential environmental impacts of proposed projects, to evaluate alternative approaches, and to design and incorporate appropriate prevention, mitigation, management and monitoring measures (FAO, 2012).

v. Environmental impact assessment (EIA) is a process which can be used to improve decision-making and ensure that development options under consideration are environmentally, socially and economically sound and sustainable. It is concerned with identifying, predicting and evaluating the foreseeable impacts, both beneficial and adverse, of proposed development projects and alternatives (Mwalyosi et al., 1999).

vi. The International Association for Impact Assessment (IAIA, 1999) defines an environmental impact assessment as "the process of identifying, predicting, evaluating and mitigating the biological, technical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made.

vii. An environmental impact assessment is an appraisal of the possible positive or negative impacts that a proposed project may have on the environment, together consisting of the environmental, social and economic aspects.

The environmental impact assessment's definitions are anticipatory in nature as they provide a means of ensuring that projects conform to require levels of environmental performance and in doing so improve the sustainability of the proposals and enhance the probability of gaining consent. The definitions are aimed at eliminating or minimising negative

impacts and optimising positive impacts through mitigation and enhancement measures. Environmental impact assessment definitions are considered as a process rather than a particular activity with the environmental impact study itself being only one component of the process.

3.2 History of Environmental Impact Assessment

Environmental impact assessment originates from the introduction of the National Environmental Policy Act (NEPA) of the United States, in 1969 as a key tool in environmental management. While such assessment had been practiced in one form or another long before the 1970s, it is perhaps after the United Nations Conference on the Human Environment. National Environmental Policy Act required that all development project proposals be accompanied by an Environmental Impact Statement (EIS) - a clear description of all potential environmental impacts, a discussion of how any adverse impacts could be avoided or mitigated, and an evaluation of alternatives to the proposed project. Environmental impact assessment is now widely institutionalised and accepted throughout the world, and interest continues to grow. These include: Fifty five countries and federations; Six multilateral development banks (including the World Bank and most regional development banks); Eleven bilateral development agencies; Eight United Nations organisations (including the United Nations Development Program, the Food and Agriculture Organisation and the World Health Organisation); Six inter-governmental organisations (including the European Commission and the Organisation for Economic Co-operation and development) (Mwalyosi et al., 1999). By the year 1996, it was estimated that over 100 countries had national environmental impact assessment systems (Sadler, 1996).

In Nigeria, Federal Environment Protection Agency (FEPA) was created by Decree 58 of 1988 as the overall body charged with the responsibility of protecting the environment in Nigeria in cooperation with Federal and State Ministries, Local Governments, statutory bodies. Federal Environment Protection Agency was scrapped in 1999 and its functions taken over by the created Federal Ministry of Environment who now administer and enforce environmental laws in Nigeria. In 1992 Nigeria join the other nations of the world to implement the use of Environmental Impact Assessment as a key tool in environmental management.

3.3 Objectives of Environmental Impact Assessment

The objectives of Environmental impact assessment include:

i. To better understand the connections between ecological, social, economic and political systems.

ii. To ensure that the environmental implications of major developments are identified.
iii. To determine if the proposed development is likely to significantly affect the environment and this would be carried out by the Government of the Federation, State or Local Government.
iv. To implement the appropriate policies in all areas where the proposed development is to take place and these must also be consistent with the State and Local Government Authority laws and decision processes.
v. To develop procedures for information exchange, notification and consultation when proposed developments are likely to have significant environmental effects on bordering towns and villages.
vi. To consider the extent, nature or location of a proposed project or activity such that it's likely to significantly affect the environment.

SELF-ASSESSMENT EXERCISE

State any four objectives of environmental impact assessment.

3.4 Functions of Environmental Impact Assessment

Environmental impact assessment is an important management tool for improving the long-term viability of projects. The use of environmental impact assessment can help to avoid mistakes that can be expensive and damaging in environmental, social and economic terms.

Environmental impact assessment is to ensure that decision makers consider the ensuring of environmental impacts when deciding whether or not to go on with a project.

Environmental impact assessment is an information provision tool which provides information to the key decision makers that will determine whether a project should be given consent. The environmental information is one of the many factors that will be taken into account, and it may or may not have a significant influence on the final decision.

Environmental impact assessment is a tool for decision-makers to identify potential environmental impacts of proposed projects, to evaluate alternative approaches, and to design and incorporate appropriate prevention, mitigation, management and monitoring measures. Environmental impact assessment cannot be separated from social impact of the project, hence the latter is considered as a key dimension of the EIA process.

Environmental impact assessment is also expected to help in ensuring protection, maintenance and rehabilitation of natural habitats and their

functions in the context of field projects and policy dialogue with countries. Environmental Assessment may be quite complex, especially if applying to broad policies and large sector programs.

The responsibility of environmental impact assessment is to address both positive and negative potential environmental impacts of the given project, any related social implications, as well as eventual trans-boundary effects.

4.0 CONCLUSION

Environmental impact assessment is a process aimed at reducing the negative impact of environmental activities caused by projects. It serves as a tool for decision-makers to identify potential environmental impacts of proposed projects, and to design and incorporate appropriate prevention, mitigation and monitoring measures.

5.0 SUMMARY

From this unit, you have learnt:

- Various definitions of environmental impact assessment.
- The spread of environmental impact assessment across different nations and institutions.
- The reasons why you need to conduct environmental impact assessment.
- You have also learnt the functions of environmental impact assessment.

6.0 TUTOR-MARKED ASSIGNMENT

1. State any two definitions of environmental impact assessment and identify the key relationship between them.
2. List any four (4) main objectives of environmental impact assessment.
3. State any three (3) functions of environmental impact assessment.

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UNIT 2 ENVIRONMENTAL IMPACT ASSESSMENT PROCESSES

CONTENTS

1.0 INTRODUCTION

Environmental impact assessment has continued to receive wide spread attention as it contributes greatly towards sustainable development. The process requires a lot of specialist, managerial skills and other stakeholders as it involves a lot of planning, organising and coordinating the tasks necessary to carry out each phase of the process and to produce a good report that will effectively inform decision makers. This decision will determine if a project should move forward or not with its development. The decisions taken contribute in minimising environmental destruction and sustain the environment for the future.

2.0 OBJECTIVES

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

- list types of environmental assessment
- list categories of environmental impact assessment
- identify stakeholder involved in the EIA Process

- explain environmental impact assessment process
- explain environmental auditing
- state components of environmental impact assessment report
- enumerate some of the challenges facing environmental impact assessment process in Nigeria.

3.0 MAIN CONTENT

3.1 Types of Environmental Assessment

Environmental assessments are carried out by various stakeholders and to meet numerous urgent objectives. The different types of environmental assessment include:

3.1.1 State of the Environment

State of the environment (SOE) as a type of environmental assessment has been largely the preserve of government, through a department or ministry mandated to undertake such an assessment and to report to parliament or government or for public information. Traditional SOE reporting has the objective of providing information on the environment and the trends in its key variables. It is mainly concerned about the biophysical environment and less about the human dimension except in the context of the pressures humanity exerts on the environment. It gives information on what is happening to the environment. This information is very useful and may be used to analyse trends in key component parameters of the environment.

3.1.2 Integrated Environmental Assessment and Reporting

State of the environment (SOE) reporting has evolved into Integrated Environmental Assessment and reporting (IEA). This is with the emergence of the concept of sustainable development, practitioners of environment assessment responded with the introduction of integrated environmental assessment, which integrates social, economic and environmental issues in the analyses. Integrated environmental assessment and reporting tries to show the cause-effect linkages of human and natural action on the environment, and in turn, the resultant environmental change in the state of the environment and human well-being. The end result of environmental assessment should be more than just knowing the state of the environment. It should give policy makers and other stakeholders some guidance on how to better manage the environment. It gives us an inventory of available resources which can be used as a starting opportunity for working towards sustainable development.

It requires the development of appropriate measures to assess existing and changing pressures and opportunities in the environment, and

achievements in reducing or containing these pressures and increasing available opportunities in a progressive movement towards sustainable development.

3.1.3 Environmental Impact Assessment

Environmental impact assessment is considered as one of the most famous type of environmental assessment. Often in the past, developers have viewed EIA as a tool used by environmentalists to undermine development. However, it is a tool used to determine the social, economic and environmental impacts of major developments in order to determine the necessary mitigatory measures. It is considered as a policy response, along with other policies such as multilateral environmental agreements and natural resource management laws and institutions. Ultimately, the aim of an environmental assessment is to ensure that developments are sustainable and do not detrimentally affect people's lives or the natural environment (SAIEA 2005).

3.1.4 Strategic Environmental Assessment

Strategic environmental assessment helps in decisions related to both environmental protection and sustainable development by:

a) Providing broader concept or vision of the environment.
b) Considering the effects of proposed strategic actions (policy, program and plan).
c) Identifying the best practicable environmental option.
d) It provides early warning of cumulative effects and large-scale changes.
e) Contributing to integrated policy-making and planning.

3.1.5 Corporate Environmental Assessment and Reporting

The private sector has become a major player in producing annual environmental reports, which assess their environmental performance in production. About 25 per cent of all Global Fortune 500 companies now produce some type of report that charts their environmental, social or sustainability efforts (Oracle 2005).

3.2 Categories of Environmental Impact Assessment

Environmental impact assessment screen projects into three categories to determine if there is need to undertake EIA or not. The predictive nature and severity of potential environmental and social impacts determine which category of environmental impact assessment a project is considered to be classified.

a) **Category A:** This is a project considered to be mandatory for environmental impact assessment. Such projects are likely to have significant environmental impacts that are sensitive, diverse or unprecedented. The projects within this category may involve significant, cumulative or even potentially irreversible negative environmental impacts or risks. These impacts may affect an area broader than the communities benefiting from infrastructural investments. Some examples of category A project by Nigerian law include: Agriculture **(**500 ha. or more), airport (2,500 meters or more), drainage (100 ha.), irrigation schemes (5,000 ha.), land reclamation (50 ha.), fisheries (50 ha.), forestry (500 ha.), industry (50 ha.), road, railways, port, mining, petroleum, quarries, power generation and transmission, waste treatment and disposal and water supply.

b) **Category B:** If the projects potential adverse environmental impacts on human populations or environmentally important areas are less adverse than those of Category A projects. These impacts are site-specific; few if any of them are irreversible; and in most cases mitigation measures can be designed more readily than for Category A projects.

c) **Category C:** If the project is likely to have minimal or no adverse environmental impacts. Once the project is assessed and determined as Category C, no further action would be required. Some examples of Category C projects include: Education (i.e. capacity-building, etc., not including school construction) Family planning (World Bank 1999).

3.3 Who is Involved in Environmental Impact Assessment Process?

An environmental impact assessment will involve a number of different stakeholders. Successful EIAs are characterised by a clear efforts being made to actively involve the team members. These include:

i. **Project proponents** are those who are responsible for commissioning and paying consultant for the EIA process. Proponents usually include government ministries and departments, private sector companies and development agencies.

ii. **Environmental Impact Assessment practitioners or service providers** are the people or institutions who undertake or provide inputs to the EIA process. They include individuals; organisations; research and academic institutes; NGOs; and both local and international consulting companies.

iii. **Reviewers** are responsible for screening or determining the level of environmental assessment required, and ensuring that the environmental impact assessment process proceeds according to the agreed comprehensive terms of reference. They also review the environmental impact assessment process and communicate their findings to decision-makers and other stakeholders. Members may be recruited from government ministries, universities and colleges, and environmental Non Governmental Organisations, together with local and international experts. They may consider as those who are responsible for quality control.

iv **Decision-makers** are those responsible for making decisions on project development once an environmental impact statement has been submitted. They may include central government, local authorities and development agencies.

v **The public** are considered as the most important stakeholders, because they contribute ideas and information that can help to avoid unforeseen problems, improve project design and contribute to monitoring. Experience also shows that development projects imposed on local communities often fail or under-perform because they lack a sense of local ownership and public support.

3.4 Environmental Impact Assessment Process

The order of the steps in conducting environmental impact assessment process may vary depending on the project. Some basic steps in conducting environmental impact assessment process are outlined below especially for a new development/project (FAO, 2012; Medupin, 2011; Mwalyosi et al., 1999).

1. Consideration of alternatives
2. Screening
3. Scoping
4. Baseline study
5. Prediction of “likely significant” impacts
6. Proposed mitigation measures
7. Public consultation
8. Submission of EIA report
9. Grant of consent by a competent authority
10. Monitoring and Audit

Consideration of Alternatives

Environmental impact assessment should start early by providing an environmental information on the decisions on what is to be constructed and where it is to be located. This provides the best opportunity to avoid

significant environmental effects by steering clear of environmentally sensitive locations and selecting designs and processes that have a reduced environmental impact.

Screening refers to the decision as to whether an EIA is required or not. Three categories of projects are defined:

a. Category A projects – EIA is mandatory.
b. Category B projects – Screening determines whether or not EIA is required.
c. Category C projects – EIA is not required.

Scoping seeks to identify at an early stage, from all of a project's possible impacts and from all the alternatives that could be addressed, those that are the crucial, significant issues.

The description of the project/development action includes a clarification of the purpose and rationale of the project, and an understanding of its various characteristics— including stages of development, location and processes.

The description of the environmental baseline includes the establishment of both the present and future state of the environment, in the absence of the project, taking into account changes resulting from natural events and from other human activities.

The identification of the main impacts brings together the previous steps with the aim of ensuring that all potentially significant environmental impacts (adverse and beneficial) are identified and taken into account in the process.

The prediction of impacts aims to identify the magnitude and other dimensions of identified change in the environment with a project/action, by comparison with the situation without that project/action.

The evaluation and assessment of significance assesses the relative significance of the predicted impacts to allow a focus on the main adverse impacts.

Mitigation involves the introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts.

Public consultation and participation aim to ensure the quality, comprehensiveness and effectiveness of the EIA, and that the public's views are adequately taken into consideration in the decision-making process.

Environmental Impact Statement (EIS) presentation refers to the report writing which is a vital step in the process. If done badly, much good work in the environmental impact assessment may be negated. For the environmental impact assessment process to achieve its objectives, it is important that any report produced is accurate, contains all the relevant information, clearly written and understood by the public, non-technical people and decision makers.

Review involves a systematic appraisal of the quality of the environmental impact statement (report), as a contribution to the decision-making process.

Decision-making on the project involves a consideration by the relevant authority of the EIS (including consultation responses) together with other material considerations.

Post-decision monitoring involves the recording of outcomes associated with development impacts, after a decision to proceed. It can contribute to effective project management.

Auditing follows from monitoring. It can involve comparing actual outcomes with predicted outcomes, and can be used to assess the quality of predictions and the effectiveness of mitigation. It provides a vital step in the EIA learning process.

SELF-ASSESSMENT EXERCISE

State the basic components of environmental impact process.

3.5 Environmental Auditing

Environmental auditing refers to the systematic, documented, periodic and objective review of practices related to meeting environmental requirements. In environmental impact assessment, audit refers to the comparison of actual and predicted impacts for the purpose of assessing the accuracy of predictions and the effectiveness of impact management practices and procedures. In most instances, the auditing process will depend heavily on the existence of relevant and good quality monitoring data. An audit can help environmental impact assessment process managers to learn from experience, and further refine and improve the environmental impact assessment process as a whole. The audit of specific environmental impact assessments can also help encourage compliance with approval terms and conditions, and provide an opportunity to re-think environmental management practices as the project progresses through the project cycle. In conducting an environmental audit the following questions have to be considered:

- What environmental impacts were predicted for the project concerned?

- When and where were the predictions stated?
- What actual impacts have been monitored?
- Where are the results recorded?
- How do actual impacts compare with predicted impacts?

3.6 Environmental Impact Assessment Report Format

Although environmental impact assessment regulations often specify the minimum contents of an environmental impact statement (report), they often do not provide any standards for report presentation. More specific guidelines for contents of an environmental impact assessment are usually specified in the terms of reference of an environmental impact assessment study of a particular project. It embraces the first four elements of: gathering environmental information; describing the project; predicting and describing the environmental effects of the project; and defining ways of avoiding, reducing or compensating for the adverse effects. The EIA report in its presentation must contain:

- Executive Summary
- Project Justification
- Project and Process Description
- Description of Project Environment / Baseline Data
- Identification of Associated and Potential Impacts
- Mitigation measures
- Environmental Management Plan
- Conclusion and Recommendations
- Bibliography / References
- Appendices

SELF-ASSESSMENT EXERCISE

Explain what you understand by environmental impact statement.

3.7 Challenges of Environmental Impact Assessment System and Practice in Nigeria

Some of the challenges facing environmental impact assessment practice in Nigeria include:

i. Inconsistent environmental management policies
ii. Poor environmental awareness within the industrial establishment
iii. Weak regulatory framework
iv. Weak organisational structure to enforce environmental impact assessment system
v. Multiple regulators at the Federal and State levels
vi. Alternatives rarely considered
vii. Low quality reports
viii. Manpower issues and technical competence

ix. Public consultation seldom enforced
x. Poor funding
xi. Ineffective coordination
xii. Non-cooperation of local communities (Medupin, 2011).

4.0 CONCLUSION

Environmental assessments varied in their categories and involve a lot of interaction with various stakeholders to meet the numerous objectives. Certain development projects according to the law are mandatory based on their scope to conduct environmental impact assessment. Some of the mandatory projects include airport, railway, waste dump sites, large farm and others.

5.0 SUMMARY

From this unit, you have learnt:

- The types and categories of environmental impact assessment.
- The various stakeholders required for success of environmental impact assessment
- Stages involve in environmental impact assessment process.
- Approach to conducting environmental auditing.
- Format for writing of environmental impact assessment report.
- The challenges facing environmental impact assessment practice in Nigeria.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain any two types of environmental impact assessment.
2. List categories of environmental impact assessment.
3. Environmental impact assessment process involves many people, identify stakeholders involve in the environmental impact assessment process for it to be successful.
4. Explain principal steps necessary for the success of environmental impact assessment process.
5. Explain briefly what you understand by an environmental auditing.
6. Enumerate the components of environmental impact assessment report.

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