COURSE GUIDE

SLM 508
LAND RECLAMATION

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Printed 2019, Reprinted 2023

ISBN:978-978-058-896-0

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INTRODUCTION

Reclamation of land is a course that deals with rehabilitation of soils subjected to soil degradation which occurs through the deterioration of the physical, chemical and biological properties of soil that results in soil compaction, salinisation, acidification, sodification and soil loss from wind and water erosion, climate change, deforestation, desertification, soil pollution and water pollution. The causes, effect and management of each form of degradation will be discussed to have a proper understanding of the how they will be reclaimed. Reclamation of lands with adverse chemical properties consists in removing harmful salts by leaching, lowering soil acidity by applying lime, raising soil nutrient-supplying power by distributing fertilisers, and introduction of proper crop rotation with higher ratio of grass. Lands liable to water and wind erosion generally includes the measures aimed at reducing the quantity and lowering the rate of running down surface water, raising soil resistivity to erosion and dispersion. Depending on a concrete purpose, different types of reclamation will be treated, this may include; reclamation oriented towards removing excessive moisture from an area called drainage reclamation, and the one intended to eliminate water shortage in the soil of agricultural fields which is referred to as irrigation.

WHAT YOU WILL LEARN IN THIS COURSE

This course carries two credit units.

This course guide tells you briefly what to expect from reading this course material. The study of land reclamation can only be possible after experiencing the nature and causes of soil degradation, which are mostly natural and human induced. These degradation processes may lead to deterioration of physical properties of the soils like; destroying soil structure and reducing porosity, leading to a more dense soil that is hard for crop roots and water penetration, altering the chemical properties of the soils leading to the formation of acidic, saline or sodic soils and other sources. Determining the level of some of these causes to know the severity of the degradation using standard laboratory procedures and understand their effects on crop production. The Land reclamation techniques were discussed with the view of improving soil productivity and keeping viable farming, as well as ensuring guaranteed agricultural production based on maintaining and improving land fertility, as well as efficient use of natural resources.

COURSE AIM

The course aims to provide a good understanding of the different types of soil degradation with their reclamation techniques for sustainable agricultural production.

COURSE OBJECTIVES

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

- explain the concepts of land reclamation and soil degradation
- explain the different types/forms of soil degradation
- know the causes, effects and management of the different types of soil degradation.
- know how to determine their level of severity
- appreciate the different reclamation techniques.

WORKING THROUGH THIS COURSE

This course has been carefully put together bearing in mind the fact that an introductory component of the course has been taught previously. However, efforts have been made to ensure adequate explanation of the concepts and issues treated in the work. You are advised to spend good time to study the work and ensure that you attend tutorial sessions where you can ask questions and compare your knowledge with that of your classmates.

COURSE MATERIALS

You will be provided with the following materials:

1. A Course Guide
2. Study Units

In addition, the course comes with a list of recommended text books which are not compulsory for you to acquire or read, but are essential to give you more insight into the various topics discussed.

STUDY UNITS

The course is divided into 15 units. The following are the study units contained in this course:

Module 1

Unit 1 Concept, Meaning and Scope of Land Reclamation
Unit 2 Types/ Forms of Soil Degradation in Agriculture I
Unit 3 Types/ Forms of Soil Degradation in Agriculture II
Unit 4 Compaction, Forms, Causes, Effect, Measurement, Prevention/Control
Unit 5 Soil Pollution, Types, Causes, Effects, Prevention/Control

Module 2

Unit 1 Water Erosion, Types, Factors Influencing, Effects and Control
Unit 2 Wind Erosion, Types, Factors Influencing, Effects, Prevention/Control
Unit 3 Acidification, Types, Causes , Effects And Correction
Unit 4 Salinisation, Sources/Causes, Effects, Measurement and Management
Unit 5 Sodification, Sources/Causes, Effects, Measurement and Management

Module 3

Unit 1 Waste , Sources, Effects and Management
Unit 2 Climate Change, Effects and Mitigation
Unit 3 Deforestation: Causes, Effects, Prevention and Control.
Unit 4 Desertification: Causes, Effects, Prevention and Control.
Unit 5 Land Reclamation Technologies for Degraded Soils

Module 1

In unit one you will be taken through the definition of land reclamation and soil degradation. You will also be taken through the meaning of soil degradation which focuses on soil erosion by water and wind, deterioration in soil physical, chemical and biological properties, waterlogging, and the build-up of toxicities, particularly salts, in the soil. In unit two you will be taken through the different forms of soil degradation. This continued up to unit three. Compaction as a form of soil degradation, with its forms, causes, effect, prevention and control will be discussed in unit four. In unit five, you will be taken through soil pollution, types, causes, effects prevention and control.

Module 2

In unit one, you will learn about the different forms of water erosion, its causes, impact on the soil and crop, factors influencing water erosion, and how it will be controlled or prevented. Wind erosion will be discussed in unit two, the type of wind erosion, factors influencing it, its effect on crop and soil and how I will be controlled or prevented. You will be taken through Acidification, the types of acidification, causes, effects and how it will be corrected in unit three. The concept of salt affected soils will be discussed in the next 2 units. In unit four, salinisation, causes, effects, measurement and management will be treated. Sodification, causes, effects, measurement and management will be handled in unit five.

Module 3

Unit one introduces you to different sources of waste, their effect on soil and management techniques. Climate change is discussed in unit two, the effect of climate change on the soil and mitigation strategies. Deforestation as a means of soil degradation is treated in unit three, the cause of deforestation, effects and prevention or control. In unit four, you will learn about desertification, its causes, effects on the soil and crop and how it will prevented or controlled. The different strategies in reclaiming degraded soils and how the reclaimed soils will be managed will be treated in unit five.

TEXT BOOKS AND REFERENCES

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ASSESSMENT

There are two components of assessment for this course. They are the Tutor-Marked Assignment (TMA), and the end of course examination.

TUTOR-MARKED ASSIGNMENT

The TMA is the continuous assessment component of your course. It accounts for 30% of the total score. The TMAs will be given to you by your facilitator and you will return it after you have done the assignment.

FINAL EXAMINATION AND GRADING

This examination concludes the assessment for the course. It constitutes 70% of the whole course. You will be informed of the time for the examination.

SUMMARY

This course intends to provide you with the knowledge of forms and causes of soil degradation in agriculture and strategies for reclaiming degraded soils. By the end of this course you will be able to answer the following questions.

- Differentiate between concepts of “soil degradation” and land “reclamation”
- Explain the characteristics of the different forms of soil degradation
- Define and explain compaction as a means of soil degradation
- Explain the term soil pollution. List and explain its major sources.
- Compare and contrast between soil and water erosion.
- Define a saline soil, and explain how you can identify saline soil on the field and laboratory.
- Discus the concept of sodification and explain how to measure sodicity.
- An extremely acidic soil may not be suitable for some crops. Discuss.
- Differentiate between deforestation and desertification
- Climate change leads to soil degradation. Discuss.
- Explain the different reclamation techniques used on degraded soils.

We wish you success in this course and hope that you will have a better understanding of the agro climatic phenomena in your environment.

Best of Luck.

MAIN COURSE

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MODULE 1

UNIT 1 CONCEPT, MEANING AND SCOPE OF LAND RECLAMATION

CONTENTS

1.0 INTRODUCTION

As the ratio of people to land steadily rises, people see little choice but to clear and burn steep, forested slopes or plow up natural grasslands to plant their crops. Population pressures have also led to overgrasing of rangelands and overexploitation of timber resources. All these activities lead to a downward spiral ecological deterioration, land degradation and deepening poverty. Degradation of soil quality by erosion which removes the top soil, little by little is caused by mismanagement of forest, farms and range land. Another wide spread cause of land degradation is the accumulation of salts in improperly irrigated soils. When farmers cultivate the soils and harvested their crops without returning organic residues and mineral nutrients, the soils supply of organic matter and nutrients becomes depleted.

Such depletion is particularly widespread where degraded soil quality is reflected in diminished capacity to produce food, contamination of a soil with toxic substances from industrial processes or chemical spills can degrade its capacity to provide habitat for soil organisms, to grow plants that are safe to eat, or to safely recharge ground and surface

waters. Degradation of soil quality by pollution is usually localised, but the environmental impacts and costs involved are very large.
The term land, as employed in land evaluation, land use planning, etc., has a wider meaning than just soil. It refers to all natural resources which contribute to agricultural production, including livestock production and forestry. Land thus covers climate and water resources, landform, soils and vegetation, including both grassland resources and forests.

Land reclamation is defined as the process of improving lands to make them suitable for a more intensive use. Reclamation efforts may be concerned with the improvement of rainfall-deficient areas by irrigation, the removal of detrimental constituents from salty or alkali lands, the diking and draining of tidal marshes, the smoothing and re vegetation of strip-mine spoil areas, and similar activities.

2.0 OBJECTIVES

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

- define soil degradation
- define land reclamation
- understand the concept of soil degradation
- understand the principles of land reclamation.

3.0 MAIN CONTENT

3.1 Soil Degradation

It is the temporary or permanent lowering of the productive capacity of soil. It thus covers the various forms of soil degradation, adverse human impacts on water resources, deforestation, and lowering of the productive capacity of rangelands. Degradation of soil resources focuses on soil erosion by water and wind, deterioration in soil physical, chemical and biological properties, waterlogging, and the build-up of toxicities, particularly salts, in the soil. Since soil productivity is intimately connected with water availability, lowering of the groundwater table is also noted. Deforestation is also being considered primarily as a cause of soil degradation, particularly erosion. Land degradation has both on-site and off-site effects. On-site effects are the lowering of the productive capacity of the land, causing either reduced outputs (crop yields, livestock yields) or the need for increased inputs. Off-site effects of water erosion occur through changes in the water regime, including decline in river water quality, and sedimentation of river beds and reservoirs. The main off-site effect of wind erosion is overblowing, or sand deposition.

1. differentiate between soil degradation and land degradation
2. discuss the effect of soil degradation in our lives

3.2 Land Reclamation

The term land, as employed in land evaluation, land use planning, etc., has a wider meaning than just soil. It refers to all natural resources which contribute to agricultural production, including livestock production and forestry. Land thus covers climate and water resources, landform, soils and vegetation, including both grassland resources and forests. Land reclamation is defined as the process of improving lands to make them suitable for a more intensive use. While protecting soil quality must be the first priority, it is often necessary to attempt to restore the quality of the soils that have already been degraded. More efforts may be required to restore degraded soils. Reclamation efforts may be concerned with the improvement of rainfall-deficient areas by irrigation, the removal of detrimental constituents from salty or alkali lands, the diking and draining of tidal marshes, the smoothing and re vegetation of strip-mine spoil areas, and similar activities.

Land reclamation can also be considered as a management practice that is usually associated with resource extraction. It is the process of returning damaged land to its original condition or to an acceptable condition through land smoothing and/or critical area planting. Steep slopes and high walls are usually taken down to a stable grade for safety and drainage. In addition, missing or poorly functional natural resources are often restored to a condition that is consistent with the surrounding area. This may include the application of topsoil, vegetation, proper drainage, and landscaping practices. Land reclamation frequently requires inputs which are costly, labour-demanding or both. The reclamation projects in salinised and waterlogged irrigated areas demonstrate this fact clearly. In other cases, the land can only be restored by taking it out of productive use for some years, as in reclamation forestry. The cost of reclamation or restoration to productive use, of degraded soils is invariably less than the cost of preventing degradation before it occurs.

1. Define Land reclamation.
2. Explain the concept of land reclamation.

4.0 CONCLUSION

The study of soil degradation and land reclamation essentially revolves around the knowledge of adverse natural and human influences on soil and water resources leading to a reduction in the productive capacity of the soils and the restoration or reclamation measures to restore their productive capacity.

5.0 SUMMARY

In this unit we have learnt that:

1. Soil degradation is caused by natural and human made factors.
2. The concept of land is broader than the concept of soil.
3. Land reclamation is defined as the process of improving lands to make them suitable for a more intensive use.
4. Land reclamation may involve improvement of rainfall-deficient areas by Irrigation.

6.0 TUTOR-MARKED ASSIGNMENT

The cost of reclamation or restoration to productive use, of degraded soils is invariably less than the cost of preventing degradation before it occurs. Discuss.

7.0 REFERENCES/FURTHER READING

Brady, N.C. & Weil, R.R. (2008). *The Nature and Properties of Soils*. (14th ed.). Pearson Education, Inc., Upper Saddle, New Jersy07458.

UNIT 2 FORMS/TYPES OF SOIL DEGRADATION IN AGRICULTURE I

CONTENTS

1.0 INTRODUCTION

As earlier discussed, soil degradation occurs in natural and human induced forms. These includes; compaction due to rainfall and overgrasing, erosion caused by wind and water, soil and water pollution, waste disposal, salinity and sodicity in arid or irrigated areas, soil acidity and many others. All these results in lowering of the productive capacity of our soils. These forms/types of soil degradation will be discussed in this unit.

2.0 OBJECTIVES

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

- know the different forms/types of soil degradation
- understand the characteristics of identified soil degradation types.

3.0 MAIN CONTENT

3.1 Compaction

Soil compaction occurs when soil particles are compressed together, especially when the soil is wet, destroying soil structure, reducing porosity, and leading to a more dense soil that is hard for crop roots and water to penetrate. Changes in agricultural practices, such as increased number of field operations and larger equipment, have made soil compaction more common on many fields. Field operations, such as silage crop harvest when the soil is wet, can lead to severe soil compaction. Compaction due to grazing is short-lived due to freeze/thaw cycles, and the total weight of grazing animals is often not sufficient to initiate deeper compaction. However, soil pudding (trampling of soil by animals under very wet conditions) can occur due to overgrazing, resulting in structural breakdown at the soil surface and subsequent crust formation when the soil dries out.

3.2 Erosion

Is the movement of soil particles by natural processes such as wind and water. Soil erosion normally occurs very slowly on undisturbed soils with natural vegetation. It is only when soils are cultivated for arable cropping or are intensively grazed that soil erosion and degradation can become an issue. On cropped land erosion can cause losses of nutrient rich topsoil as well as (in severe cases of wind erosion), total crop loss and deposition of soil sediment on roads and into water courses. Soil runoff of nutrients, organic matter and pesticides can also affect water quality and habitats. The increase in soil erosion to date is strongly linked with the clearance of natural vegetation, to enable land to be used for arable agriculture, and the use of farming practices unsuited to the land on which they are practiced. This, combined with climatic variation and extreme weather events, has created ideal conditions for soil erosion. Soil erosion is accelerated by a marked landscape slope, removal of vegetation to create agricultural land, drought, soil tillage, wind, or water, but erosion by water is the most widespread and serious. This is because the force of gravity on water and ice may lower the shear strength of landscape slopes, making soils behave like plastics or, under very moist conditions, like fluids.

3.3 Soil Pollution

Soil contaminants are all products of soil pollutants that contaminate the soil. Human activities that pollute the soil range from agricultural practices that infest the crops with pesticide chemicals to urban or industrial wastes or radioactive emissions that contaminate the soil with various toxic substances. Soil pollution refers to the presence of a chemical or substance out of place and/or present at a higher than normal concentration that has adverse effects on any non-targeted organism. Although the majority of pollutants have anthropogenic origins, some contaminants can occur naturally in soils as components of minerals and can be toxic at high concentrations. Soil pollution often cannot be directly assessed or visually perceived, making it a hidden danger.

3.4 Waste

Waste is any plastics, paper, glass, metal, foods, chemicals, wood, oil, soil, effluents, liquids that have been discarded. How the waste gets generated is from commercial, household and industrial sources. Sewage sludge is another source. Domestic and municipal waste is generated by the consumption of goods, manufacturing, sewage treatment, agriculture, the production & disposal of hazardous substances and construction. They are essential parts of the process of production as the emission of carbon dioxide by human is part of breathing process. From time immemorial, waste disposal has been a problem, and after industrialization the problem has only compounded. In the past, trash was carried to the outskirts of cities and discarded in the open, but now that can no longer be done. Over time, various waste disposal methods have been devised, like compost, burning, landfill, biological reprocessing, etc.

3.5 Soil Acidification

Soil acidification has been identified as one of the forms of soil degradation. Soil acidity is defined as the preponderance of hydrogen and aluminium ions in the soil leading to low pH value. Soil becomes acidic because the basic cations (calcium, magnesium and potassium) in the soil are replaced by hydrogen and aluminium. This is identified by measuring soil reaction (pH) which is the negative logarithm of the soil hydrogen ion concentration. pH is expressed on a scale from 1-14. Because the pH scale is logarithmic, soil with pH of 5 is 10 times more acidic than soil with pH of 6 and is 100 times more acidic than soil with pH 7. Remember that, the lower the pH number, the more acid the soil is and the greater the need for reclamation (liming). The reaction of the soil is alkaline when the pH value is above 7.0, neutral at 7.0 and acidic below 7.0.in practical terms, soils between pH 6.5 to 7.5 are considered neutral. Soils in the range of 5.6 to 5.0 are moderately acidic and below 5.5 strongly acidic. Acidification of top soils, and more seriously, sub soils will lead to lower yields, reduced pasture and crop options and contribute to wider catchment problems such as weed infestations, salinity and erosion.

4.0 CONCLUSION

Soil degradation is the decline in any or all of the characteristics which make soil suitable for producing food. Soil degradation occurs through the deterioration of the physical, chemical and biological properties of soil that results in soil compaction, pollution, acidification, and waste and soil loss from wind and water erosion.

5.0 SUMMARY

In this unit we have learnt that:

1. Soil compaction destroys soil structure and reduces porosity at the soil surface leading to subsequent crust formation preventing penetration of crop roots and water.
2. The two main agents of erosion are water and wind.
3. Majority of soil pollutants have anthropogenic origins, while some can occur naturally in soils as components of minerals.
4. Waste is generated from commercial, household, agricultural and industrial sources.
5. Soil acidification as a mean of soil degradation may lead to low crop yield and reduce crop options.

6.0 TUTOR-MARKED ASSIGNMENT

Among the soil degradation forms discussed, which amongst them is the most detrimental and why?

7.0 REFERENCES/FURTHER READING

Brady, N.C. (1974). *The Nature and Properties of Soils.* (8th ed.). Macmillan Publishing Co.Inc.,New York, U.S.A.

Donahue, R.L., R.W. Miller, & Shickluna. J.C. (1983). *Soils: An Introduction to Soils and Plant Growth.* (5th ed.). Prentice Hall Inc.,Englewood Cliffs, New Jersey.

UNIT 3 FORMS/TYPES OF SOIL DEGRADATION IN AGRICULTURE II

CONTENTS

1.0 INTRODUCTION

As earlier discussed, soil degradation occurs in natural and human induced forms. These includes; compaction due to rainfall and overgrazing, erosion caused by wind and water, soil and water pollution, waste disposal, salinity and sodicity in arid or irrigated areas, soil acidity and many others. All these, results in lowering the productive capacity of our soils. These forms/types of soil degradation will be discussed in this unit.

2.0 OBJECTIVES

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

- know the different forms/types of soil degradation
- understand the characteristics of identified soil degradation types.

3.0 MAIN CONTENT

3.1 Soil Salinisation

Saline soils contain excessive concentrations of soluble carbonate, chloride and sulfate salts that cause EC levels to exceed 4 dS/m. Although relatively insoluble salts such as Ca and Mg carbonates do not cause high EC levels, they are often present in saline soils and may result in the formation of a white crust on the soil surface. The primary challenge of saline soils on agricultural land is their effect on plant/water relations. Excess salts in the root zone reduce the amount of water available to plants and cause the plant to expend more energy to exclude salts and take up pure water. Additionally, if salinity in the soil solution is great enough, water may be pulled out of the plant cell to the soil solution, causing root cells to shrink and collapse. The effect of these processes is 'osmotic' stress for the plant. Osmotic stress symptoms are very similar to those of drought stress, and include stunted growth, poor germination, leaf burn, wilting and possibly death.

3.2 Soil Sodification

Sodic soils have a relatively low EC, but a high amount of Na^+ occupying exchange sites, often resulting in the soil having a pH at or above 8.5. Instead of flocculating, Na^+ causes soil colloids to disperse, or spread out, if sufficient amounts of flocculating cations (i.e., Ca^{2+} and Mg^{2+}) are not present to counteract the Na^+. Dispersed colloids clog soil pores, effectively reducing the soil's ability to transport water and air. The result is soil with low water permeability and slow infiltration that causes ponding and then crusting when dry. These conditions tend to inhibit seedling emergence and hinder plant growth. Sodic soils are also prone to extreme swelling and shrinking during periods of drying and wetting, further breaking down soil structure. The subsoil of a sodic soil is usually very compact, moist and sticky, and may be composed of soil columns with rounded caps. Fine-textured soils with high clay content are more prone to dispersion than coarser textured soils because of their low leaching potential, slow permeability and high exchange capacity. Other symptoms of sodic soils include less plant available water, poor tilth and sometimes a black crust on the surface formed from dispersed organic matter.

3.3 Climate Change

Greenhouse gases such as carbon dioxide (CO2) absorb heat (infrared radiation) emitted from Earth's surface. Increases in the atmospheric concentrations of these gases cause Earth to warm by trapping more of this heat. Human activities—especially the burning of fossil fuels since the start of the Industrial Revolution—have increased atmospheric CO2 concentrations by about 40%, with more than half the increase occurring since 1970. Since 1900, the global average surface temperature has increased by about 0.8 °C (1.4 °F). This has been accompanied by warming of the ocean, a rise in sea level, a strong decline in Arctic sea ice, and many other associated climate effects. Much of this warming has occurred in the last four decades. Detailed analyses have shown that the warming during this period is mainly a result of the increased concentrations of CO2 and other greenhouse gases. Continued emissions of these gases will cause further climate change, including substantial increases in global average surface temperature and important changes in regional climate. The magnitude and timing of these changes will depend on many factors, and slowdowns and accelerations in warming lasting a decade or more will continue to occur. However, long-term climate change over many decades will depend mainly on the total amount of CO_2 and other greenhouse gases emitted as a result of human activities.

3.4 Deforestation

Deforestation is the conversion of forested areas to non-forested land. It is the large scale removal of forests resulting to non-forest to meet various human needs. Logging, expansion of agricultural croplands, urbanization, fuel wood collection, mining and resources extraction, fire-hunting and slash and burn practices have been identified as the key drivers of deforestation. Deforestation of dry lands destroys the trees and vegetation that bind the soil, and because of the prevailing climatic conditions in dry lands, the possibility of regeneration of denuded vegetation is low and hence, the land becomes desertified.

3.5 Desertification

Desertification is defined as a process that causes land degradation due to some prevailing climatic conditions and human activities such that it resulted into the inability of the environment to sustain the demands being made upon it by socio-economic systems at existing levels of technology and economic development. Desertification entails the formation and expansion of degraded areas of soil and vegetation cover in arid and semi-arid and seasonally dry areas, caused by climatic variations and human activities. It involves denuding and degrading a once fertile land, initiating a desert producing cycle that feed on itself and causing long term changes in soil, climate and biota of an area.

Desertification is an advanced stage of land degradation where soil has lost part of its capability to support human communities and ecosystem. In areas undergoing desertification, people in their quest for food and desired livelihood to support the population, pursue land management and cultivation practices that deplete soils of their nutrient and organic matter content and promote erosion; overgrazing of rangelands, and cut trees and bushes for fuel wood and other purposes. The direct effect of desertification on land degradation is either decrease of land productivity or the complete abandonment of agricultural land, which ultimately lead to the food crisis experienced in many arid and semi-arid regions especially Africa.

4.0 CONCLUSION

Soil degradation is the decline in any or all of the characteristics which make soil suitable for producing food. Soil degradation occurs through the deterioration of the physical, chemical and biological properties of soil that results in soil, salinisation, sodification, climate change, deforestation and desertification.

5.0 SUMMARY

In this unit we have learnt that:

1. Salinization may manifest in form of white crust on the soil surface and wilting of the plant despite the presence of moisture due to poor osmotic pressure.
2. Soil sodification is as a result of sodium ion causing soil colloids to disperse and making it impermeable with slow infiltration.
3. Continued emissions of Co_2 and other greenhouse gases will cause further climate change, including substantial increases in global average surface temperature and important changes in regional climate.
4. Deforestation is considered to be one of the contributing factors to global climate change.
5. Desertification entails the formation and expansion of degraded areas of soil and vegetation cover in arid and semi-arid and seasonally dry areas, caused by climatic variations and human activities.

6.0 TUTOR-MARKED ASSIGNMENT

1. Enumerate the differences and similarities between sodification and salinisation.
2. What are the major differences and similarities between deforestation and desertification? How does the two affect climate change?

7.0 REFERENCES/FURTHER READING

Brady, N.C. (1974). *The Nature and Properties of Soils.* (8^{th} ed.) Macmillan Publishing Co.,Inc.,New York, U.S.A.

Donahue, R.L., Miller, R.W. & J.C. Shickluna. (1983). *Soils: An Introduction to Soils and Plant Growth*. (5th ed.). Prentice Hall Inc.,Englewood Cliffs, New Jersey.

UNIT 4 SOIL COMPACTION: FORMS, CAUSES, EFFECTS, MEASUREMENT, PREVENTION/CONTROL

CONTENTS

1.0 INTRODUCTION

Soil compaction affects many agricultural fields and can lead to yield reductions if not properly managed. Understanding soil's physical components will help you understand how compaction affects the soil.

2.0 OBJECTIVES

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

- know the different types/ forms of soil compaction
- identify the various causes of soil compaction
- recognise the effects of soil compaction
- know how to measure soil compaction
- identify the methods of preventing/alleviating soil compaction.

3.0 MAIN CONTENT

3.1 Soil Compaction

Soil compaction can happen at any layer in the soil and is classified into two major types surface and subsurface depending on where in the soil profile it occurs.

3.1.1 Forms of Soil Compaction

The two major types of soil compaction are ;(i) surface and (ii)subsurface compactions. Surface compaction is when the dense soil layer occurs at the surface of the soil. This kind of soil hardening at the surface is also called soil crusting. Surface compaction happens when the surface soil aggregates are broken down through the impact of falling raindrops, runoff, standing water during irrigation, or tillage. Soil aggregates are the distinct arrangement of soil particles into "clumps" or "units," and these units are bound together more strongly than the adjacent soil. If the aggregates are broken down, the soil particles become rearranged into a thin, continuous, dense layer on the soil surface. When this thin layer dries up, a crust is formed uniformly across the soil surface, creating a compacted layer that restricts water and air entry and impedes seedling emergence. Impacts from the hooves of grazing animals (especially under overgrazing conditions) can also contribute to the breakdown of the surface soil aggregates and subsequent soil crusting.

(ii) Subsurface compaction is the one in which the compacted layer is found at a depth within the soil. This type of compaction may be natural or human-caused. Natural compaction occurs due to soil-forming processes and is normally found in the subsoil. Subsurface compaction can also be caused by modern agricultural practices such as tillage, use of heavy farm equipment, and farm traffic. For example, plowing the soil at the same depth for several years may cause a compacted layer just beneath the plow layer, which is called a "plow pan" Compaction caused by farm operation can negatively affect the quality of the surface soil (0–12 inches) and make fields less productive for crop production.

3.1.2 Causes of Soil Compaction

Forces responsible for soil compaction include; natural and human induced causes. These include:

Raindrop impact
This is certainly a natural cause of compaction leading to the formation of a soil crust that may prevent seedling emergence. Drops of rain cause splash erosion, which disturbs the top layer of soil particles and causes formation of a thin surface crust that blocks water from reaching plant roots.

Tillage operations

Tilling the soil accelerates breakdown of organic materials that inhibit compaction. It can also damage soil structure, the arrangement of mineral particles in relation to pore space, especially if soil is tilled when it is wet. Repeated tillage orients all of the soil particles in the same direction, causing a layer of compacted soil (a plow pan) to form directly beneath the area being tilled. Plow pans are mainly a problem on farm fields where the soil is consistently tilled at the same depth. Continuous mouldboard plowing or disking at the same depth will cause serious tillage pans (compacted layers) just below the depth of tillage in some soils.

Wheel traffic

Heavy farm machinery can create persistent subsoil compaction. An axle load of 10 Mg can cause compaction to penetrate to a depth of 50 cm, and with still higher loads, compaction can reach 1 m deep. Loads as high as 30 Mg per axle are used in many countries. Consequently, soil compaction resulting from farm machinery has become a major concern in agriculture worldwide. Soil is also compacted during building construction, from repeated use of riding lawn mowers, or from off-road parking of automobiles and recreational vehicles. Pedestrian pathways across garden beds and turf areas are also significant contributors to compaction.

Minimal crop rotation

The trend towards a limited crop rotation has had two effects: (1) Limiting different rooting systems and their beneficial effects on breaking subsoil compaction, and (2) Increased potential for compaction early in the cropping season, due to more tillage activity and field traffic.

Natural processes

Soils with high clay content—typical of wetlands and river bottoms—can become compacted due to natural processes. Because individual clay particles are so small, they are more susceptible to being pressed together tightly.

Pasture grazing

There is a tendency for the soil to become compacted after continuous grazing of animals on the field. Regardless of the type of grazing system soil bulk density is increased at field moist condition, and that this effect was most pronounced at soil depths less than 10 cm. poor grazing management is one of the major causes of soil compaction in agricultural land, this is because, livestock traffic develops soil compaction due to repeated pressure in the area due to poor grazing management. Although livestock can break the upper layer of the soil due to hoof action, deep compaction layers develop overtime if left untreated. Soils that are higher in clay content are more susceptible to hoof compaction than sandier soils. He further reiterated that aeration can decrease soil compaction and allow for greater plant root development.

3.1.3 Effects of Soil Compaction

Compaction caused by farm operations has been shown to affect the yield of field crops in several ways:

i. It creates a dense soil layer that is veryhard for roots to penetrate. Roots tend to grow laterally when they hit this compaction zone. This severely limits the volume of soil that the roots can explore for water and nutrients.
ii. Compacted soil also limits the movement of water into the soil, thereby creating conditions that favor soil erosion and runoff. With much of the water running off, or being evaporated in the case of irrigated lands, the amount of water that goes into the soil and is made available for crop use is limited.
iii. Less water will be available in the soil for crop use due to the abundance of micro pores that are holding the water tightly because of the destruction of medium and large pores by compaction.

Actual yield loss by compaction varies depending on crop type, growing environment, and any practices adopted to offset compaction. Some crops are known to penetrate hardpan better than others. If the crop is frequently irrigated or receives frequent rainfall, then root restriction by hardpan may be less detrimental.

3.1.4 Measurements of Soil Compaction

Cone penetrometer

Cone penetrometer has been used to measure the actual pressure a root meets when growing into a soil. The applied force required to press the penetrometer into a soil is an index of the shear resistance of the soil and is called the cone index‖ (CI). Thus, CI gives the specifications of the actual probe and the force required to press the probe into the soil.

CI can be described: CI = $\frac{F}{\pi d2/4}$

Where

F = total pressure needed to force the penetrometer into the soil (Newtons, N), The denominator is the base area of the cone, and d is the diameter of the cone.

CI is measured in Pascals (Pa) or N/m2. CI is dependent on soil and probe characteristics, including cone-base diameter, cone angle, and the surface roughness of the cone, as well as penetration rate and the immediate condition of the soil - primarily moisture content and texture. One should interpret penetration resistance information very carefully because many factors can significantly affect it, including soil type, soil strength, soil water content, penetration rate, cone size and shape, and surface roughness of the cone.

Surface Nuclear Gauges (SNGs)
The SNG was developed for quality control of subgrade and base material compaction during road construction. Because the instrument is currently in use on construction sites, SNGs have also been used as an alternative to traditional excavation methods for determining bulk densities. When using a surface nuclear gauge, two independent measurements are determined: 1) the wet density of the soil, and 2) the soil moisture content. Wet density is measured by the suppression of gamma waves from a probe lowered from the gauge into the soil. Moisture content is measured immediately below the gauge, as the amount of reflected neutrons hitting the hydrogen in the water. By subtracting moisture content from wet density, dry bulk density is obtained. Both measurements may be derived within a minute.

3.1.5 Prevention/Alleviation of Compaction

Precision traffic agricultural practice
Farmers are advised to carryout precision traffic agricultural practice and to avoid several passes of wheel traffic on agricultural land; more over planting of crops on soils with cone index of more than 1.5 kPa should be avoided.

Deep tillage practices
Deep tillage practices, normally referred to as subsoiling should be carried out on soils confirmed to be compacted. This is aimed at restoring the lost soil properties and involves loosening compacted soil layers below the ploughing depth, without inverting them. Subsoiling leads to improved root growth and water and nutrient infiltration.

Cultivating cover crops
Farmers are advised to cultivate cover crops like mucuna and brassica which may help alleviate effects of soil compaction. Thus as mucuna leaves fall to the ground, they form thick mat of biomass. This biomass conserves moisture and provides organic matter encouraging earthworm

activities which reduces soil bulk density and nutrients to the soil surface, alleviating soil compaction and restoring soil fertility.

Incorporating organic matter into the soil
Incorporating Organic Matter into the soil promotes stable soil structure. This material acts as a binder to hold soil aggregates together. Incorporation of organic manure into the soil is done by retaining previous crop residues on the soil surface; growing small grains that have grass-like rooting systems; growing green manure crop in rotation; and applying animal manures, sludge, or other waste products. This strengthens soil structure, adds nutrients and organic carbon.

Practicing mixed farming
Practicing mixed farming helps to alleviate soil compaction. Thus, an area is cropped for some years (3 - 4 years) and left under pasture for two or more years before returning to it. Mixed farming helps to alleviate soil compaction.

Reduce secondary tillage
Decreasing the number of secondary tillage trips preserves the soil aggregates and decreases susceptibility to compaction, while over tilling ‘destroys the natural soil structure while continuing to decrease soil pore size. Each tillage operation breaks down soil aggregates and decreases the pore space necessary for good air and water flow. As a result, the soil becomes more susceptible to implement compaction and crusting.

4.0 CONCLUSION

The major types of soil compaction are surface and subsurface, caused by natural and human induced influences which lead soil degradation and ultimately affecting the yield of field crops.

5.0 SUMMARY

In this unit we have learnt that:

1. Compaction is one of the forms of soil degradation.
2. Compaction can be caused by natural and human induced influences.
3. Cone penetrometer and surface nuclear gauges can be used to measure soil compaction.
4. Methods of preventing/ alleviating soil compaction like; precision traffic agriculture, reduce secondary tillage, deep tillage, cultivating cover crops have been discussed.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the effect of surface and subsurface compaction on soil and how it affects crop yield?
2. Explain how cone penetrometer can be used to measure soil compaction.

7.0 REFERENCES/FURTHER READING

FAO (2005). *Land and Environmental Degradation and Desertification in Africa:* FAO, Rome.

UNIT 5 SOIL POLLUTION: TYPES, CAUSES, EFFECT, PREVENTION/CONTROL

CONTENTS

1.0 INTRODUCTION

Soil pollution can result from both intended and unintended activities. These activities can include the direct deposition of contaminants into the soil as well as complex environmental processes that can lead to indirect soil contamination through water or atmospheric deposition.

2.0 OBJECTIVES

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

- know the different types/ forms of soil pollution
- identify the various sources of soil pollution
- recognise the effects of soil pollution
- identify the approaches of managing or remediating soil pollution.

3.0 MAIN CONTENT

3.1 Soil Pollution

3.1.1 Forms of Soil Pollution

i. **Point-source pollution:** Is soil pollution caused by a specific event or a series of events within a particular area in which contaminants are released to the soil, and the source and identity of the pollution is easily identified. Anthropogenic activities represent the main sources of point-source pollution. Examples include former factory sites, inadequate waste and wastewater disposal, uncontrolled landfills, excessive application of agrochemicals, spills of many types, and many others. Activities such as mining and smelting that are carried out using poor environmental standards are also sources of contamination with heavy metals in many regions of the world. Point-source pollution is very common in urban areas.

ii. **Diffuse pollution:** is a pollution that is spread over very wide areas, accumulates in soil, and does not have a single or easily identified source. Diffuse pollution occurs where emission, transformation and dilution of contaminants in other media have occurred prior to their transfer to soil. Diffuse pollution involves the transport of pollutants via air-soil-water systems. Complex analyses involving these three compartments are therefore needed in order adequately to assess this type of pollution. For that reason, diffuse pollution is difficult to analyze, and it can be challenging to track and to delimit its spatial extent. Many of the contaminants that cause local pollution may be involved in diffuse pollution, since their fate in the environment is not well understood. Examples of diffuse pollution are numerous and can include sources from nuclear power and weapons activities; uncontrolled waste disposal and contaminated effluents released in and near catchments; land application of sewage sludge; the agricultural use of pesticides and fertilisers which also add heavy metals, persistent organic pollutants, excess nutrients and agrochemicals that are transported downstream by surface runoff; flood events; atmospheric transport and deposition; and/or soil erosion

3.1.2 Sources of Soil Pollutants

Natural, geogenic sources

Background concentrations in the soils of a region will be strongly related to the pedo-geochemical fraction and the dynamics of the environment that led to the formation of the soil. Several soil parent materials are natural sources of certain heavy metals and other elements, such as radionuclides, and these can pose a risk to the environment and human health at elevated concentrations. Soils and rocks are also natural sources of the radioactive gas Radon (Rn). High natural radioacti vity is common in acidic igneous rocks, mainly in feldspar-rich rocks and illite-rich rocks. Natural events such as volcanic eruptions or forest fires can also cause natural pollution when many toxic elements are released into the environment.

Anthropogenic sources

Centuries of anthropogenic activities have resulted in a widespread problem of soil pollution around the world. The main anthropogenic sources of soil pollution are the chemicals used in or produced as by-products of industrial activities, domestic and municipal wastes, including wastewater, agrochemicals, and petrol-derived products. These chemicals are released to the environment accidentally, for example from oil spills or leaching from landfills, or intentionally, as is the case with the use of fertilizers and pesticides, irrigation with untreated wastewater, or land application of sewage sludge. Anthropogenic pollutant sources include;

i. **Industrial activities:** The range of chemicals used in industrial activities is vast, as is their impact on the environment. Industrial activities release pollutants to the atmosphere, water and soil. Gaseous pollutants and radionuclides are released to the atmosphere and can enter the soil directly through acid rain or atmospheric deposition; former industrial land can be polluted by incorrect chemical storage or direct discharge of waste into the soil; water and other fluids used for cooling in thermal power plants and many other industrial processes can be discharged back to rivers, lakes and oceans, causing thermal pollution and dragging heavy metals and chlorine that affect aquatic life and other water bodies. Heavy metals from anthropogenic activities are also frequent in industrial sites and can arise from dusts and spillages of raw materials, wastes, final product, fuel ash, and fires. potentially polluting activities can be grouped into six main categories: 1) energy industries; 2) production and processing of metals; 3) mineral industry; 4) chemical industry and chemical installations; 5) waste management; and 6) other activities (which include paper and board production, manufacture of fibers or textiles, tanning of hides and skins, slaughterhouses, intensive poultry or pig rearing, installations using organic solvents, and the production of carbon or graphite).

ii. **Mining:** Mining has had a major impact on soil, water and biota since ancient times. Mining and smelting facilities release huge quantities of heavy metals and other toxic elements to the environment; these persist for long periods, long after the end of these activities. Toxic mining wastes are stocked up in tailings, mainly formed by fine particles that can have different concentrations of heavy metals. These polluted particles cnan be dispersed by wind and water erosion, sometimes reaching agricultural soils.

iii. **Urban and transport infrastructures:** The widespread development of infrastructure such as housing, roads and railways has considerably contributed to environmental degradation. Their more evident negative effects on soil are soil sealing and land consumption. Apart from these known soil threats, another major impact of infrastructure activities is the entry into the soil system of different pollutants. Despite its being a major threat, soil pollution from infrastructure activities has received very minor consideration in terms of planning and impact assessment. Soil pollution associated with roads and highways is especially important in urban and peri-urban soils, and can be a major threat when food production occurs in adjacent areas. Municipal waste disposal by landfills, illegal or not, and untreated wastewater release into the environment are important sources of heavy metals, poorly biodegradable organic compounds and other pollutants which enter the soil.

iv. **Waste and sewage generation and disposal:** As the global population increases, so does the generation of waste. Municipal waste disposal in landfills and incineration are the two most common ways to manage waste. In both cases, many pollutants, such as heavy metals, polyaromatic hydrocarbons, pharmaceutical compounds, personal care products and their derivative products accumulate in the soil, either directly from landfill leachates that may be polluting soil and under groundwater, or by ash fallout from incinerating plants. The use of sewage sludge to amend soils may be beneficial, as it adds organic matter and nutrients to soils. However, if that sewage sludge has not been pre-treated before its application, many pollutants such as heavy metals can accumulate in the soil and eventually enter the food chain. The use of treated wastewater for agricultural irrigation is common in arid and semiarid regions as a solution to water scarcity. The use of wastewater can, however, be an issue in countries where water quality guidelines and legislation do not exist. Improper use of wastewater can lead to the deposition of heavy metals, salts, PPCPs and pathogens, if they are not completely removed after treatment or in cases where wastewater is left untreated.

v. **Military activities and wars:** The First and Second World Wars left Europe with a significant heritage of pollution (land mines, remains of ammunitions and leftover chemicals, radioactive and biological toxic agents), not only in the battlefields but also in sites such as shooting areas, barracks and storage of armaments. This legacy has made the soils in some of these areas unsuitable for any kind of exploitation or service provision.

vi. **Agricultural and livestock activities**: The different agricultural sources of soil pollutants include agrochemical sources, such as fertilizers and animal manure, and pesticides. Trace metals from these agrochemicals, such as, Cu, Cd, Pb and Hg, are also considered soil pollutants as they can impair plant metabolism and decrease crop productivity. Water sources for irrigation can also cause soil pollution if they consist of waste water and urban sewage. Livestock production can also be a source of pollution, especially if the waste is not properly managed and disposed of: the urine and faeces may contain parasites and medical substances that can persist and accumulate in the soil. Excessive application of fertilizers and manure or inefficient use of the main nutrients (N and P) in fertilizers is the main contributors to environmental issues linked to agriculture. These two nutrients are a source of diffuse pollution. Excessive fertilizer usage can lead to soil salinity, heavy metal accumulation, water eutrophication and accumulation of nitrate, which can be a source of environmental pollution but also a threat to human health. The use of pesticides has helped provide food for an increasing population similarly to the application of nutrients; however, the over use of pesticides can have negative effects on human health and the environment.

3.1.3 Effects of Soil Pollution

Entry of pollutants directly (release of effluents on land) or indirectly (use of polluted water as irrigation to crops) has been reported to contaminate vast areas of soil resources and groundwater bodies, affecting crop production as well as human and animal health through food contamination. Effects of soil pollution on soil degradation manifest itself in the following ways:

Synthetic fertilisers

Modern agriculture practices accelerate soil pollution with the intensive use of fertiliser and pesticides in order to increase productivity and reduce crop losses. When pollutants reach high levels in the soil, not only do soil degradation processes take place, but crop productivity can also be affected. Therefore, in addition to endangering human health and the environment, soil pollution can also cause economic losses. Excess N in soil has been identified as the main cause of soil acidification and salinization through nitrification and other N-transformation processes. Soils acidify very slowly under natural conditions over hundreds to millions of years, but this process is significantly accelerated by agricultural practices, mainly excessive N fertilisation, which causes reductions in soil pH by 0.26 pH units on average in different land uses.

Acidification and crop loss

Acidification of agricultural soils may contribute to further soil pollution, through the mobilization of toxic heavy metals. If the content of nitrogen applied to agricultural soils is higher than the plants' requirements, nitrification microbial activity will lead to the accumulation of nitrates (NO3-) that can easily leach to groundwater due to their high solubility, polluting it. When soil nutrient availability increases, microbial biomass and activity increases as well, but the microbial biodiversity is altered, causing imbalances in the nutrient cycle.The main risk from P fertilizers is transport to surface water bodies, which has been documented to cause eutrophication of aquatic ecosystems in many regions. The P is transported to water bodies adsorbed to eroded soil particles or from excessive amounts of P fertilizer or animal manure applied when conditions are not suitable (Syers, Johnson and Curtin, 2008). Many farmlands receive more P inputs than the amount that crops are able to take up, causing a soil-P surplus, at least in the short term.

Pesticides

An extensive review of scientific research about the effects of pesticide use on soil functions was recently undertaken by the Intergovernmental Technical Panel on Soil. The main scientific-based evidence presented in this work showed an increase in the farmers' net return when they applied pesticides; however the benefits of pesticide use are usually assessed by comparing use of synthetic pesticides versus no use of pesticides rather than comparing synthetic pesticides to biological control of pests. Negative associated impacts of specific pesticides on soil organisms and soil functions have been also reported. For example, some organochlorine pesticides suppress symbiotic nitrogen fixation, resulting in lower crop yields. The FAO and ITPS report also highlights the knowledge gap on the relationship between pesticides and soil health, mainly on soil pollution.

Manure

Application of untreated manure may lead to heavy metal pollution, which not only results in adverse effects on various parameters relating to plant quality and yield, but also causes changes in the size, composition and activity of the microbial community (Yao, Xu and Huang, 2003) affecting nutrient cycling and reducing nutrient availability. As previously discussed, a high proportion of antibiotics given to livestock is poorly assimilated in the animals' guts and is excreted in urine and faeces. Untreated manure can thus contain high amounts of veterinary antibiotics (VA) that can lead to a rapid increase in antibiotic resistance in soils. The fate and effects of antibiotics in soils have gained great attention in the last few years, motivated in part by the results of the O'Neill commission report, which estimates that antimicrobial resistant infections may become the leading cause of death in the world by 2050.

Urban wastes in agriculture

Considering that the positive effects of sewage sludge amendment – such as waste reduction, nutrient cycling, increase of soil fertility, improvement of soil structure and water holding capacity – are significantly more important than the negative effects, efforts should focus on reducing the content of pollutants in sewage sludge and wastewaters used for irrigation. As highlighted by Petrie et al., the lack of knowledge on the fate of emerging pollutants and other pollutants present in wastewater and sewage sludge can be solved only by analysing them before land application. Composting and pretreatments reduce the content of contaminants and pathogen organisms present in urban waste before their application as amendments in soils, and provide an economical and environmentally friendly approach for stabilising animal waste and converting it into a worthy organic fertiliser. Frequently, however, high levels of heavy metals such as Pb, Cd, Cu, Zn, Cr, Ni, and salts remain in the amendments and may affect soil properties and inhibit plant growth.

Management and remediation of polluted soils

Risk assessment approaches (RAA)

This is the first step to be taken in managing or remediating polluted soils. Risk Assessment Approaches are similar worldwide and consist of a series of steps to be taken to identify and evaluate whether exogenous or indigenous substances have caused or are causing soil pollution, and to what extent that pollution is posing a risk to the environment and to human health. The management of polluted sites is a site-specific approach that includes characterisation, risk assessment and remediation technologies selection, and therefore is mainly focused on local or point-source contamination:

- New technologies for remediation involve the application of nanoparticles for remediating polluted soils. The most widely recognised nanotechnology in soil remediation is the application of nano-zero-valent iron (nZVI) for reducing the impact of both organic and inorganic pollutants. For example, nZVI can effectively degrade chlorinated hydrocarbons and organochlorine pesticides. Carbon nanotubes have been demonstrated to be a feasible remediation material because of their large sorption capacity for metal ions, radionuclid and organic compounds.

- The planting of trees that have good resistance to high levels of toxic substances and a high capacity to collect and store pollutants can also be a good practice for bioremediation process in soils. According to Wisłocka et al., the most popular trees exhibiting a high capacity to accumulate heavy metals are silver birch (Betula pendula), alder (Alnus tenuifolia), black locust (Robinia pseudoacacia), willow (Salix sp.), and conifer trees. Selected energy crops such as Miscanthus giganteus have excellent adaptability to change habitat conditions, the possibility to gradually reclaim degraded lands, and the ability to prevent the migration of heavy metals into the soil and groundwater.
- The addition of manure and sewage sludge can be an effective bioremediation tool, but care needs to be taken to ensure that effective pre-treatment of the organic material has occurred. To attenuate the negative impacts associated with livestock manure, simple techniques such as composting can be applied before their application to the land. Compared to fresh manure, composted manure generally has higher contents of lignin and polyphenol, which reduces CH4 emission while further enhancing the potential of SOC sequestration.

4.0 CONCLUSION

Soil contaminants are all products of soil pollutants that contaminate the soil. Human activities that pollute the soil range from agricultural practices that infest the crops with pesticide chemicals to urban or industrial wastes or radioactive emissions that contaminate the soil with various toxic substances

5.0 SUMMARY

In this unit we have learnt that:

- The two forms of soil pollution are; point source and diffuse pollution.
- The major source of soil pollutants are; natural/geogenic and anthropogenic.
  Effects of soil pollution on soil degradation manifest itself inform of; synthetic fertiliser, acidification and crop loss, urban waste, manure etc.
- Risk assessment approach is the first stage to be considered in managing or remediating soil polluted sites.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the effect of synthetic fertiliser and manure in soil pollution.
2. Discuss the Anthropogenic sources of soil pollutants.

7.0 REFERENCES/FURTHER READING

Polluting Our Soil is Polluting Our Future/FAO stories (2018) www.fao.org-stories article. May 2, 2018.

Soil pollution: A Hidden Reality-FAO. www.fao.org>

MODULE 2

UNIT 1 WATER EROSION: TYPES, FACTORS INFLUENCING IT, EFFECTS AND CONTROL

CONTENTS

1.0 INTRODUCTION

The main variables affecting water erosion are precipitation and surface runoff. Raindrops, the most common form of precipitation, can be very destructive when they strike bare soil. With impacts of over 20 mph, raindrops splash grains of soil into the air and wash out seeds. Overland flow, or surface runoff, then carries away the detached soil, and may detach additional soils and then sediment which can be deposited elsewhere.

2.0 OBJECTIVES

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

- know the different types and forms of water erosion
- identify the factors influencing water erosion
- recognise the effects of forms of water erosion
- identify the methods of preventing/alleviating water erosion.

3.0 MAIN CONTENT

3.1 Types of Water Erosion

As precipitation progresses, water film on the soil surface thickens particularly when the infiltration capacity of the soil has been exceeded. This water film slides down slope, and as it moves it carries with it soil particles. When the water film further thickens, it will become rivulets which having stronger tractive force can move not only soil but also gravel. The water moving the soil from place to place is called runoff. This phenomenon is so familiar that many people commonly believe that the process of transportation is the only process of soil erosion. It must however be noted that it is through the transportation process that severe soil erosion occurs. Deposition when runoff reaches flat lowland, the current slows down depositing its content. This is the last stage of accelerated erosion. Deposition usually occurs in depressions or at the foot slope. The amount of soil delivered into a stream divided by the amount eroded is termed the delivery ratio. Typically the delivery ratio is larger for small watershed than for large ones. Types of water erosion.

3.1.1 Splash Erosion

Raindrops hitting soil aggregates tear it apart by its kinetic energy. The soil particles are splashed as a consequence of this action.

3.1.2 Sheet Erosion

When precipitation exceeds soil permeability, excessive water will form a thin sheet or film of about 0.1 to 3.00 mm thick. This film of water or film current moves over the soil sometimes with small ripples. In the process, splashed soil is removed more or less uniformly. This is termed sheet erosion. Sheet erosion removes fine particles and organic matter without any easily detectable trace. Sheet erosion is the uniform removal of soil in thin layers by the forces of raindrops and overland flow. It can be a very effective erosive process because it can cover large areas of sloping land and go unnoticed for quite some time. Sheet erosion can be recognized by either soil deposition at the bottom of a slope, or by the presence of light - colored subsoil appearing on the surface. If left unattended, sheet erosion will gradually remove the nutrients and organic matter which are important to agriculture and eventually lead to unproductive soil.

3.1.3 Rill and Interill Erosion

Rills are channel which could be obliterated easily by normal tillage operations. A rill is always no more than 30 cm depth and 100 cm in width. They are formed when water has accumulated on the ground, and the film of water becomes streamlets which have greater scouring action than sheet flow. Rills can easily be formed along furrows planted along slopes. Interrill (between rills) erosion is sometimes referred to as sheet erosion; but technically, interill erosion is the detachment and transport of particles by rain impact and shallow overland flow.

3.1.4 Gully Erosion

When rills advance, gullies are formed. These are erosion channels too large to be obliterated by ordinary tillage. In gullies, runoff develops as powerful torrents with enhanced capability of erosion. Gullies have different shapes, depending on soil texture, and bedrock characteristics. They can be shallow troughs, V-shaped, U-shaped or complex in shape. A gully is active when its walls are free of vegetation and inactive when they are stabilized. Apart from shapes, gullies can also be classified according to depth. Small gully < 1 m deep Medium gullies: 1-5 m deep Large gully: > 5 m deep A channel is concentrated flow path for water leaving a field or watershed. Channels may be permanent waterways or may be tilled across. Erosion in channels is mostly caused by downward scour due to flow shear stress. Side wall sluffing can also occur during widening of the channel caused by large flows. Channel erosion can be the first stage in development of a classical gully. Classical gullies are an advanced stage of channel erosion. They are formed when channel development has progressed to the point where the gully is too wide and too deep to be tilled across. These channels carry large amounts of water after rains and deposit eroded material at the foot of the gully. They disfigure landscape and make land unfit for growing crops.

3.1.5 Ephemeral Gullies

Ephemeral gullies, on the other hand, can be plowed in and tilled across depending upon their depth and width. They are somewhat transitory rather than permanent like classical gullies. Ephemeral gullies are produced by concentrated flow in topographically controlled locations. Meaning they will reform in the same location in a field where flow from upslope regions.

3.1.6 Landslides

Landslides, and other mass failures, occur when the underlying layers of soil are more saturated and erodible than the outer layers. Gravity moves soil directly. Soil movement caused by gravity is known as landslide, mudflow, slip, slump, soil creep, and surface creep. As water seeps through the surface it acts as a lubricant and causes the outer layers to detach. Then gravitational forces take over and cause the mass to slide rapidly to the foot of the hill or the bottom of the gully. Soil covered by natural forest even on steep slopes is usually in equilibrium with its environment, and this makes soil movement to be extremely low. When soil cover is destroyed or greatly reduced by overgrazing, logging, cultivation, surface mining or construction, the development of excess moisture in the soil after heavy rainfall events causes normal friction between the underlying material and the semi viscous soil mass to reduce, and the mass slowly or rapidly slides downhill.

3.2 Factors Influencing Soil Erosion by Water

Climate (rainfall and runoff)
The potential ability of rainfall to cause soil erosion is called erosivity. In evaluating rainfall erosivity, rainfall should first be perceived as an aggregation of different drops of water. Then it can further be perceived in amount as the summation of the amount of individual drops. The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter are easily removed by the raindrop splash and runoff water; greater raindrop energy or runoff amounts are required to move larger sand and gravel particles.

Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during short-duration, high-intensity thunderstorms. Although the erosion caused by long-lasting and less-intense storms is not usually as spectacular or noticeable as that produced during thunderstorms, the amount of soil loss can be significant, especially when compounded over time. Surface water runoff occurs whenever there is excess water on a slope that cannot be absorbed into the soil or is trapped on the surface. Reduced infiltration due to soil compaction, crusting or freezing increases the runoff. Runoff from agricultural land is greatest during spring months when the soils are typically saturated, snow is melting and vegetative cover is minimal.

Soil

Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Texture is the principal characteristic affecting erodibility, but structure, organic matter and permeability also contribute. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam-textured soils tend to be less erodible than silt, very fine sand and certain clay-textured soils. Tillage and cropping practices that reduce soil organic matter levels, cause poor soil structure, or result in soil compaction, contribute to increases in soil erodibility. As an example, compacted subsurface soil layers can decrease infiltration and increase runoff. The formation of a soil crust, which tends to "seal" the surface, also decreases infiltration.

On some sites, a soil crust might decrease the amount of soil loss from raindrop impact and splash; however, a corresponding increase in the amount of runoff water can contribute to more serious erosion problems. Past erosion also has an effect on a soil's erodibility. Many exposed subsurface soils on eroded sites tend to be more erodible than the original soils were because of their poorer structure and lower organic matter. The lower nutrient levels often associated with subsoils contribute to lower crop yields and generally poorer crop cover, which in turn provides less crop protection for the soil.

Topography

The steeper and longer the slope of a field is the higher the risk for erosion. Soil erosion by water increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water, which permits a greater degree of scouring (carrying capacity for sediment).

Vegetation

The potential for soil erosion increases if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of runoff water and allows excess surface water to infiltrate. The erosion-reducing effectiveness of plant and/or crop residues depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil and intercept all falling raindrops at and close to the surface are the most efficient in controlling soil erosion (e.g., forests, permanent grasses). Partially incorporated residues and residual roots are also important as these provide channels that allow surface water to move into the soil.

The effectiveness of any protective cover also depends on how much protection is available at various periods during the year, relative to the amount of erosive rainfall that falls during these periods. Crops that provide a full protective cover for a major portion of the year (e.g., alfalfa or winter cover crops) can reduce erosion much more than can crops that leave the soil bare for a longer period of time (e.g., row crops), particularly during periods of highly erosive rainfall such as spring and summer. Crop management systems that favour contour farming and strip-cropping techniques can further reduce the amount of erosion. To reduce most of the erosion on annual row-crop land, leave a residue cover greater than 30% after harvest and over the winter months, or inter-seed a cover crop (e.g., red clover in wheat, oats after silage corn).

Human behavior (Tillage Practices)

The potential for soil erosion by water is affected by tillage operations, depending on the depth, direction and timing of plowing, the type of tillage equipment and the number of passes. Generally, the less the disturbance of vegetation or residue cover at or near the surface, the more effective the tillage practice in reducing water erosion. Minimum till or no-till practices are effective in reducing soil erosion by water.

Tillage and other practices performed up and down field slopes creates pathways for surface water runoff and can accelerate the soil erosion process. Cross-slope cultivation and contour farming techniques discourage the concentration of surface water runoff and limit soil movement.

3.3 Effects of Water Erosion

On-site

The implications of soil erosion by water extend beyond the removal of valuable topsoil:

- Crop emergence, growth and yield are directly affected by the loss of natural nutrients and applied fertilizers.
- Seeds and plants can be disturbed or completely removed by the erosion.
- Organic matter from the soil, residues and any applied manure is relatively lightweight and can be readily transported off the field, particularly during spring thaw conditions.
- Pesticides may also be carried off the site with the eroded soil.
- Soil quality, structure, stability and texture can be affected by the loss of soil.
- The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can weaken the structure and even change the texture.

- Textural changes can in turn affect the water-holding capacity of the soil, making it more susceptible to extreme conditions such as drought.

Off-site

The off-site impacts of soil erosion by water are not always as apparent as the on-site effects:

- Eroded soil, deposited down slope, inhibits or delays the emergence of seeds, buries small seedlings and necessitates replanting in the affected areas.
- Sediment can accumulate on down-slope properties and contribute to road damage.
- Sediment that reaches streams or watercourses can accelerate bank erosion, obstruct stream and drainage channels, fill in reservoirs, damage fish habitat and degrade downstream water quality.
- Pesticides and fertilisers, frequently transported along with the eroding soil, contaminate or pollute downstream water sources, wetlands and lakes.
- Because of the potential seriousness of some of the off-site impacts, the control of "non-point" pollution from agricultural land is an important consideration.

3.4 Control of Water Erosion

Part of the measures adopted to control or minimize run off is by careful and rational management of crop residues. Other approaches often adopted include:

i) Fallowing: the practice of leaving the land unplanted in alternate years or cropping the land for three years and then fallowing for the next few. This is most effective water conservation technique in areas of limited rainfall.

ii) Terraces and contouring: this is the practice of cultivating and planting and planting on strips of land that are of the same elevation. There are several different kinds of terraces all of which control runoff.

iii) Strip cropping: spreading vegetation or crops are established in a strip which is at right angles to the flow of water or the prevailing wind. This gives protection to the adjacent strips or rows of crops or fallow land.

iv) Ridging: planting crops on ridges help to reduce the effect of water runoff.

4.0 CONCLUSION

The force of falling raindrops and the grinding action of running water both speed up the rate of detachment and transportation. This may affect the Soil quality, structure, stability, texture and nutrient loss.

5.0 SUMMARY

In this unit we have learnt that:

1. Severe soil erosion occurs through the transportation processes of soil materials by water.
2. The main variables affecting water erosion are precipitation and surface runoff.
3. The off-site impacts of soil erosion by water are not always as apparent as the on-site effects.
4. Erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of the soil.
5. Water erosion can be controlled using, Fallowing, terracing and contouring, strip cropping and ridging.

6.0 TUTOR-MARKED ASSIGNMENT

1. Describe the three main steps in the water erosion processes.
2. Explain the various methods of water erosion control and state their economic implication.

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UNIT 2 WIND EROSION: TYPES, FACTORS INFLUENCING WIND EROSION, EFFECTS, PREDICTION AND CONTROL

CONTENTS

1.0 INTRODUCTION

Wind erosion is the process of detachment, transportation and deposition of soil materials by wind. The basic causes are: Loose, dry and finely divided soils, smooth and bare soil surface, Strong wind and large field.

2.0 OBJECTIVES

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

- know the different types of wind erosion
- identify the factors influencing wind erosion
- recognise the effects of wind erosion
- predict wind erosion using wind erosion predicting equation (WEQ)
- Identify the different methods of controlling wind erosion.

3.0 MAIN CONTENT

3.1 Wind Erosion

3.1.1 Forms of Wind Erosion

The three types of soil erosion by wind include:

Suspension
Soil particles and aggregates less than 0.05 mm in diameter (silt size and smaller are kept suspended by the turbulence of air currents, after being dislodged by salting particles. These particles only drop out of air if rain washes them or wind velocity reduces drastically. Suspension occurs when very fine dirt and dust particles are lifted into the wind. They can be thrown into the air through impact with other particles or by the wind itself. Once in the atmosphere, these particles can be carried very high and be transported over extremely long distances. Soil moved by suspension is the most spectacular and easiest to recognize of the three forms of movement.

Saltation
This is a process in which fine particles (0.05 (0.1) to 0.5 mm in diameter) are lifted from the soil surface by wind turbulence and follow distinct trajectories under the influence of wind forces, air resistance, and gravity. In other words, the particles move in a series of short leaps. The jumping grains gain a great deal of energy, and may knock other grains into the air or bounce back themselves. The particles remain close to the ground as they bounce. The particles are often stopped by obstructions or reduced wind velocity. Saltation **-** The major fraction of soil moved by the wind is through the process of saltation. In saltation, fine soil particles are lifted into the air by the wind and drift horizontally across the surface increasing in velocity as they go. Soil particles moved in this process of saltation can cause severe damage to the soil surface and vegetation. They travel approximately four times longer in distance than in height. When they strike the surface again they either rebound back into the air or knock other particles into the air.

Surface creep: This is the rolling and sliding along the surface of the larger particles. Soil grains larger than 0.5 mm cannot be lifted. This causes them to roll and slide along the surface after coming into contact with saltating particles. The soil aggregates or gravel which cannot be eroded are left in place to provide a cover called desert pavement or lag gravel.

3.1.2 Factors Affecting Wind Erosion

Soil moisture: Wet soil does not blow because of the adhesion between water and soil particles. Dry winds generally lower soil moisture to below wilting point before wind erosion takes place.

Wind velocity: The rate of wind movement, especially gusts having greater than average velocity will influence wind erosion. Standard wind velocity is measured at a fixed height of 9 m above the ground.

Height: Velocity of even a steady wind increases dramatically above the ground surface. Wind velocity over a bare surface is zero at a height close to the surface below the tops of irregularities.

Wind turbulence: Wind strong enough to cause erosion is always turbulent, with eddies moving in all directions at a variety of velocities. Turbulence increases with increases in friction velocity, with increasing surface roughness, and with pronounced changes in surface temperature. It is more pronounced near the soil surface than higher in the wind stream. Turbulence is important in keeping soil grains suspended in air.

Surface roughness: Wind velocity is less severe when the surface is rough. This can be achieved by tillage, ridging and/or mulching.

Soil properties: Apart from soil water content, other soil properties which influence wind erosion are (i) stability of soil aggregates, (ii) size of erodible soil fractions. The presence of clay, organic matter and other cementing agents enhance aggregate stability.

Vegetation: Vegetation or residue mulch especially those with rows running perpendicular to the prevailing wind direction reduce wind erosion. Wind velocity approaches zero near the soil surface in a vegetated area. In addition, plant roots bind the soil.

Length of exposed area: Soil drifting increases substantially with increasing length of the eroding strip.

3.1.3 Effects of Wind Erosion

- Wind erosion damages crops through sandblasting of young seedlings or transplants, burial of plants or seed, and exposure of seed.
- Crops are ruined, resulting in costly delays and making reseeding necessary.

- Plants damaged by sandblasting are vulnerable to the entry of disease with a resulting decrease in yield, loss of quality and market value.
- Wind erosion can create adverse operating conditions, preventing timely field activities.
- Soil drifting is a fertility-depleting process that can lead to poor crop growth and yield reductions in areas of fields where wind erosion is a recurring problem.
- Continual drifting of an area gradually causes a textural change in the soil. Loss of fine sand, silt, clay and organic particles from sandy soils serves to lower the moisture-holding capacity of the soil. This increases the erodibility of the soil and compounds the problem.
- The removal of wind-blown soils from fence rows, constructed drainage channels and roads, and from around buildings is a costly process.
- Soil nutrients and surface-applied chemicals can be carried along with the soil particles, contributing to off-site impacts.
- Blowing dust can affect human health and create public safety hazards.

3.1.4 Estimating the Amount of Soil Loss

A wind erosion prediction equation (WEQ) has been in use since the late 1960s:

$$E = f\ (ICKLV)$$

The predicted wind erosion E is a function f of:

I = soil erodibility factor
C = climate factor
K = soil-ridge-roughness factor
L = with of field factor
V = vegetative cover factor

The WEQ involves the major factors that determine the severity of the erosion, but it also considers how these factors interact with each other. It is not possible to predict wind erosion by simply multiplying the factors as in USLE. The soil erodibility factor I relates to the properties of the soil and the degree of the slope in question. The soil-ridge-roughness factor K takes into consideration the cloddiness of the soil surface, vegetative cover V, and ridges on the soil surface. The climatic factor C involves wind velocity, soil temperature, and precipitation (which controls soil moisture).

The width of field factor L is the width of a field in the downwind direction. Naturally the width changes as the direction of the wind changes, so the prevailing wind direction is used. The vegetative cover V relates not only to the degree of soil surface covered with residues, but to the nature of the cover-whether it is living or dead, still standing or flat on the ground.

3.1.5 Controlling Wind Erosion

The factors of wind erosion give clues to methods of reducing it. Little can be done to change climate in an area, but it is possible to alter one or more of the other factors.

- Tillage: To minimise wind erosion, the surface should be rough, in cloddy condition and with surface residues. Tillage should be carried out when the soil moisture is adequate.
- Water conservation practices which reduce loss of water through evapotranspiration include weeding, conservation tillage, and reduction of runoff through surface roughness or terraces
- The length of eroding field can be altered by strip cropping or by installing wind breaks perpendicular to the direction of the prevailing wind.
- Planting rows of shrubs or trees to serve as windbreaks or shelterbelts is effective in reducing wind erosion.
- Local recommendations for appropriate species should be followed with vegetative windbreaks. The distance protected by a windbreak may be 6 to 15 times the height of the barrier, with effectiveness decreasing with distance.
- Closely spaced crops are more effective than row crops. Alternating rows of crops such as cotton which is less-wind resistant with sorghum which is more resistant to wind is important.
- Residues should be left on the fields.

4.0 CONCLUSION

Soil particles move in three ways, depending on soil particle size and wind strength; suspension, saltation and surface creep. The rate and magnitude of soil erosion by wind is controlled by soil erodibility, surface roughness, climate, unsheltered distance and vegetative cover.

1.0 SUMMARY

In this unit we have learnt that:

1. Suspension, saltation, and surface creep are the three types of soil movements which occur during wind erosion.
2. Wind erosion can be predicted using wind prediction equation (WEQ).
3. Wind erosion can be eliminated or curtailed when: the soil is compacted to resist the force of the wind, the soil surface is roughed or covered by vegetative residue and also when wind velocity near the ground is somewhat reduced.
4. Wind erosion can be controlled by; roughening the surface soil by appropriate tillage measures, application of stubble mulch or incorporation of organic residues, strip cropping at right angles and barriers such as shelterbelts to reduce wind velocity.

6.0 TUTOR-MARKED ASSIGNMENT

1. List and explain four soil properties that characterise soils highly susceptible to wind erosion.
2. Which two factors in the wind erosion prediction equation (WEQ) can be affected by tillage and why?

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UNIT 3 SOIL ACIDIFICATION: TYPES, CAUSES AND MEASUREMENT

CONTENTS

1.0 INTRODUCTION

Soil acidification is the buildup of hydrogen cations, which reduces the soil pH. Chemically, this happens when a proton donor gets added to the soil. The donor can be an acid, such as nitric acid, sulfuric acid, or carbonic acid. It can also be a compound such as aluminium sulfate, which reacts in the soil to release protons. Acidification also occurs when base cations such as calcium, magnesium, potassium and sodium are leached from the soil.

2.0 OBJECTIVES

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

- know the different types soil acidity
- identify the causes of soil acidity
- know the effects of soil acidity
- How to correct soil acidity.

3.0 MAIN CONTENT

3.1 Soil Acidity

3.1.1 Types of Soil Acidity: Three Types of Soil Acidity Were Identified; Active Acidity

This is acidity due to the H^+ in the soil solution.

Salt-replaceable acidity
This involves the hydrogen and aluminium that are easily exchangeable by other cations in a simple un buffered salt solution such as KCl and CaCl2.

Residual acidity
Is an acidity that can be neutralised by limestone or other alkaline materials but cannot be detected by salt replaceable technique. These types of acidity all add up to the total acidity of a soil.

3.1.2 Causes of Soil Acidity

The development of soil acidity is brought about by a number of causes which include;

Parent material
Soil parent material influences the development of soil acidity; since soils formed from acidic minerals such as quartz, feldspar, granite etc frequently contain very few bases, while soils formed from limestone initially contain a high base content. Soils with low clay and organic matter content also become acidic relatively rapidly because the amount of bases that can be held on their small base exchange complex is rather low.

Climate
Acid soils form most rapidly in humid regions where rainfall appreciably exceeds evapotranspiration. Excess rainfall containing dissolved carbon dioxide andorganic acids formedin the soils percolates down the soil profile taking with them bases (mainly calcium)from the the soil base exchange complex. These bases are replaced by hydrogen ions thus increasing soil acidity. As acidity drops to a pH level of about 5.0, aluminium hydroxide in the soil is hydrolysed, a process which releases further hydrogen ions and furher lowers the soil pH.

Use of acidifying inputs
Ammonium containing fertilizers such as urea and ammonium sulphate arethe most important examples, as their useresluts in loss of basesfrom the soil.

Excessive cultivation of soil leading to crop removal of basic cations from the soil is a good contributing factor to soil acidity.

Water and **wind erosion** of rich top soil also leads to soil acidity

Acids brought in by rain; a number of gaseous sulphur and nitrogen compounds, especially SO_2 andNO_2 are emitted into the atmosphere through the natural processes and/or by man's activities. These gaseous compounds are dissolved in rains, come down to earth and are added to the soil.

3.1. 3 Effects of Acidification on Soil and Crops

Strongly acid soils pose a problem to many crops.

These include:

- Some crops regardless of the supply of available cations, just do not do well when soil reaction is acidic. There are plant physiological problems involved in which the plant metabolism or chemistry is unable to function properly.
- The physical condition of acid soil is also generally not as good as that of neutral soils. The soil aggregates in such soils are often water unstable so that soil structure is difficult to maintain. The soil particles are dispersed when the soil is wet, but on drying hard soil clod is formed.
- In many soils with very low pH, there is simply a shortage of the needed cations, resulting in deficient crops and poor growth. Where this is the case, banding of cations to achieve partial saturation of the exchange complex may furnish adequate fertility. It is a case of supplying the crop with the needed amounts of plant nutrients.
- Soil acidity controls the solubility and precipitation of chemical compounds of all essential plant nutrients and is therefore a deciding factor on their availability as it has a far reaching influence on soil fertility and plant growth.

Other effects of soil acidity includes:

- Induced calcium and phosphorous deficiencies on most crops at <4.2
- Reduced phosphate uptake as a result of precipitation of aluminium P.
- Induced manganese toxicity
- Restricted root growth, distribution and function at $pH < 5.0$
- Direct injury to plant roots through aluminium toxicity inhibits root development resulting in short thick root, often without hairs.

3.1. 4 Correction of Soil Acidity

In managing acid soils, the first step is to identify the extent and severity of the problem. Poor yields of acid sensitive crops may indicate an acid condition, but soil test are the sure method of identifying an acid problem. With careful sampling of fields, soil test can determine the extent and severity of acidity, the rate of lime required and provide an estimate of crop response to lime. A lime requirement test should be conducted to determine the amount of lime required to bring the soil to pH of 6.5.in some cases, growing crops that are more tolerant to acidity is an alternative to liming. But as soils are gradually becoming more acid, the choice of crops becomes very limited. Soil acidity can be corrected through the application of various liming materials. Liming is the application of materials containing cations usually calcium or calcium and magnesium which replaces hydrogen ions in the base exchange complex and soil solution thus raise the soil pH.

4.0 CONCLUSION

Soil acidity is one of the manifestations of soil degradation and it has physical, chemical and biological dimensions. It results in a complex change in the soil, such as the increase in toxic levels of aluminium and manganese, inhibition of microbial processes, reduction of cation exchange capacity, reduced availability of nutrients such as phosphorous reserves and diminishes solubility of molybdenum and boron. All these, contribute to lower soil productivity, lower yields and losses to farmers.

5.0 SUMMARY

In this unit we have learnt that:

- Acidification is quantified using the pH scale in the range of 0-14.
- Acidification is caused by; oxidation of sulfur and nitrogen, acid precipitation(acid rain), plant uptake of cations, carbonic and other organic acids, etc.
- The effect of acidification manifest in making the soil aggregates in to become water unstable so that soil structure is difficult to maintain and the soil particles are dispersed when the soil is wet.
- Acidified soils can be reclaimed.

6.0 TUTOR-MARKED ASSIGNMENT

1. The ill-effects of acidity in subsoil can be ameliorated by adding gypsum to the soil surface. What are the mechanisms responsible for this effect of gypsum?

2. Discuss acidification effects on soil and crops.

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UNIT 4 SALINISATION: SOURCES/CAUSES, EFFECTS, MEASUREMENT AND MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The processes that result in the accumulation of neutral soluble salts are referred to a salinisation. The salts are mainly chlorides and sulphates of calcium, magnesium, potassium and sodium. The concentration of these salts sufficient to interfere with plant growth is generally defined as that which produces an electrical conductivity in the saturation extract (EC) greater than 4 ds/m, but have an ESP less than 15, $SAR<13$ in the saturation extract. The exchange complex if saline soils are dominated by calcium and magnesium, not sodium. The pH is usually below 8.5 evpoartion of water creates a white crust on the soil surface which accounts for the name white alkali.

2.0 OBJECTIVES

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

- define salinisation and its major causes/sources
- know the effects of salinisation on soils and crops
- know how to determine saline soils on the field and in the laboratory
- possible ways of managing saline affected soils.

3.0 MAIN CONTENT

3.1 Soil Salinisation

3.1.1 Sources/Causes of Salinisation

In most cases, soluble salts originate from the followings

Parent material
Weathering of primary rocks and parent materials containing relevant salts may be a cause for salinization. In extremely dry regions, calcium sulphate accumulation (gypsic horizon) may form near the soil surface, where this relatively soluble mineral may create a saline condition. However, in most cases salts are transported to a developing salt affected soil as ions dissolved in water. The salt containing water moves through a landscape from areas of higher to lower elevations and from soil zones that are wetter to those that are drier. The water is eventually lost by evaporation. However, the dissolved salts cannot evaporate, and therefore they are left behind to accumulate in the soil.

Changes in local water balance
This is usually brought about by human activities that lead to an increase in input of the salt bearing water more than they increase the output of drainage water. Increased evaporation, waterlogging and rising water table usually results.

Saline seeps
This occurs as a result of fossil deposit of salts laid down during geological time in the bottom of now extinct lakes or oceans or in underground saline water pools. These fossils salts can be dissolved in underground waters that move horizontally over underlying impervious geological layers and ultimately rise to the surface of the soil in the low lying parts of the landscape. The salts then concentrate near or on the surface of the soil in these low-lying areas, creating a saline soil.

Irrigation
Irrigation not only alters the water balance by bringing in more water, it also brings in more salts whether taken from a river or pumped from underground water, even the best quality freshwater contains more dissolved salts. The amount of salts brought in with the water may be negligible, but the amounts of water applied over the course of time are huge. Pure water is lost be evaporation, but the salts stays and accumulate.

3.1.2 Effects of Soil Salinisation

Under saline condition, the following conditions may manifest:

- Toxicity may occur due to high concentration of Na, Cl, SO_4 or other ions.
- Crop growth is affected due to osmotic effect. High salt concentration increase the potential forces that hold water in soil and makes it difficult for plant roots to extract the moisture and nutrients even when the soil is wet.
- During the dry period or dry spell, salt in soil solution may be so concentrated as to kill plants by pulling water from them (exosmosis). This was the experience the tomatoes were going through before the rains.

3.1.3 Measurement of Salinity

In order to assist in characterising and managing saline soils, techniques have been developed to measure and quantify the degree of soil salinity. Salinity is measured using:

- Electrical conductivity (EC): pure water is a poor conductor of electricity, but conductivity increases as more and more salt is dissolved in the water. Thus, the electrical conductivity of the soil solution gives us an indirect measurement of the salt content. The EC can be measured both on samples of soils or on the bulk soil insitu. It is expressed in terms of deciSiemens per meter (ds/m). It is measured conductivity meter.
- Total dissolved solids (TDS): The simplest way to determine the total amount of dissolved salt in a sample of water is to heat the solution in a container until all of the water has evaporated and only a dry residue remains. A temperature of 180C is used to ensure that the water of hydration is removed from the salt residue. The residue can then be weighed and the total dissolved solid (TDS) expressed as milligrams of solid residue per liter of water (mg/L).

3.1.4 Management of Salinisation

For effective management of saline soils, there is need for farmer education to know the nature of the salts in the soil that need to be removed, or the soluble salts being added and removed from the soil. In irrigated areas, this means knowing the quality of irrigation water and the status of the soil drainage. However, the following specific strategies should be adopted:

- **Leaching:** sufficient quantity of water should be applied to leach the salt out of the soil and prevent the uncontrolled entry of new salts. His is however only possible if the soil is permeable and the groundwater is well below the root zone or can be brought below the root zone by drainage.
- **Water control:**
  - i. Maintaining a high water content in the soil, near field capacity, dilutes salt and lessens their toxic and osmotic effects.
  - ii. Under irrigation, light but frequent irrigation to keep the soil at a high moisture content during then salt sensitive germination and seeding stage to enhance plant survival to the normally more tolerant mature stage of growth.
  - iii. Limited leaching can be done before planting or light irrigation after planting will move more salts below the planting and early rooting zone.
  - iv. Intermittent application of irrigation water can effectively reduce the salt content to a desired level.

- **Tillage and cultivation practices**
  - i. Leveling of micro relief to eliminate differences in rainfall/irrigation infiltration improves salt removal from topsoil and encourages uniform plant growth.
  - ii. Application of organic matter will compensate for fertility loss and improve the physical structure of the soil
  - iii. Mulching prevents salt accumulation on the surface during the dry season and enables salts to be leached out in the wet season or irrigation.
  - iv. Planting positions for row crops can reduce the salt concentration around the young plant crops on the side of ridges than on the crestal position.
  - v. Split application of fertiliser is suggested, as the crop will produce healthier plants and also greater salt tolerance than a single large application of fertiliser.

- **Choice of crops**
  - i. This is based on the tolerance of crop to salinity which varies from crop to crop. They are classified into; tolerant, moderately tolerant, moderately sensitive and sensitive.

4.0 CONCLUSION

Salinisation refers to a buildup of salts in soil, eventually to toxic levels for plants. Salt in soils decreases the osmotic potential of the soil so that plants can't take up water from it. When soils are salty, the soil has greater concentrations of solute than does the root, so plants can't get water from soil. The salts can also be directly toxic, but plant troubles usually result primarily from inability to take up water from salty soils. The Problems associated with salinization are most commonly with excessive water application, rather than with too little.

5.0 SUMMARY

In this unit we have learnt that:

1. The major contributing factors in salinisation are; parent material, high water table and irrigation water.
2. Salinity can be measured/ quantified using electrical conductivity and total dissolved salts.
3. The Salts in the soils decreases the osmotic potential of the soil so that plants can't take up water from it and the plant will start wilting.
4. A soil is termed saline if in the saturation extract the (EC) is greater than 4 ds/m, and ESP is less than 15, while SAR<13.
5. Salinised soils can be reclaimed.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the primary sources of salinity in soils / explain.
2. List and explain the visible features of saline soils on the field.

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UNIT 5 SODIFICATION: SOURCES/ CAUSES, EFFECTS, MEASUREMENT AND MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The processes that result in the high accumulation of sodium in the exchange complex are referred to a sodification. sodic soils are perhaps the most trouble some of the salt affected soils. While their levels of neutral soluble salts are low (EC < 4ds/m), they have relatively high levels of sodium on the exchange complex (ESP and SAR 15and 13 respectively). The pH values of the sodic soils exceed 8.5, rising to 10 or higher in some cases. The extreme pH levels are largely due to the fact that sodium carbonate is much more soluble than calcium or magnesium carbonate and so maintain high concentration of carbonate and bicarbonate ions in the soil solution.

2.0 OBJECTIVES

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

- define sodification and its major causes/sources
- know the effects of sodification on soils and crops
- know how to determine sodic soils on the field and in the laboratory
- possible ways of managing sodic affected soils.

3.0 MAIN CONTENT

3.1 Sodification

3.1.1 Sources/Causes of Sodification

The extremely high pH levels may cause the soil organic matter to disperse and /or dissolve. The dispersed and dissolved humus moves upward in the capillary water flow and, when the water evaporates, can give the soil surface a black colour**.** If irrigation water carries a significant proportion of Na+ compared to Ca^{2+} and Mg^{2+} ions , and especially if the HCO_3**-**ion is present, sodium ion may come to saturate a major part of the colloidal exchange sites, creating an unproductive Sodic soils.

3.1.2 Effects of Soil Sodification

- Reduced flow of water through soil: which limits leaching and can cause salt to accumulate over time and the development of saline subsoil
- Dispersion in the soil surface, causing crusting and sealing, which then impedes water infiltration
- Dispersion in the subsoil, accelerating erosion, which can cause the appearance of gullies and tunnels
- Dense, cloddy and structureless soils as it destroy aggregation

Indicators of sodicity
Some common signs include:

- poor vegetation or crop growth
- poor water infiltration
- surface crusting
- dense or hard subsoil
- prismatic or columnar structure in the subsoil
- soapy feel when wetting and working up for soil textures
- pH > 8.5
- cloudy water in puddles
- Shallow rooting depth.

3.1.3 Measurement of Sodicity

Two expressions are commonly used to characterise the sodium status of soils. The exchangeable sodium percentage (ESP), identifies the degree to which the exchange complex is saturated with sodium

$$ESP = \frac{Exchangeable\ sodium}{CEC\ (pH\ 7.0)} \times 100.$$

ESP of greater than 15 is associated with severely deteriorated soil physical properties and pH of 8.5 and above.
The sodium adsorption ratio (SAR) gives information on on the comparative concentration of Na, Ca, and Mg ions in solution. It iscalculated using the formula

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

3.1.4 Management of Sodic Soils

- Drainage must be adequate.
- Replacement of some of the exchangeable Na by Ca. This is more effectively accomplished by replacing them with either Ca^{2+} ar H^+ in the form of Gypsum. The addition of gypsum leads to the formation of Na_2SO_4, which can easily be leached from the soil.

4.0 CONCLUSION

Sodification is a condition where the concentration of sodium salts is high relative to other types of salt, leading to the development of a sodic soil. Sodic soils are characterised by a poor soil structure; they have a low infiltration rate, they are poorly aerated and difficult to cultivate. Thus, sodic soils adversely affect the plants' growth and they can be reclaimed through the application of lime (Gypsum), so that; the exchangeable sodium can be replaced by exchangeable calcium.

5.0 SUMMARY

In this unit we have learnt that:

1. Sodification is process of high accumulation of sodium in the exchange complex in relation to other salts.
2. Sodic soils can be measured using ESP and SAR.
3. When the EC is less than 8, ESP>15,SAR>13 and pH>8.5, a soil is termed sodic.
4. Effects of sodicity include; poor vegetation or crop growth, poor water infiltration, surface crusting, dense or hard subsoil and prismatic or columnar structure in the subsoil.

6.0 TUTOR-MARKED ASSIGNMENT

1. An arid-region soil, when it was first cleared for cropping, had a pH of about 8.0. After several years of irrigation, the crop yield decline, the soil aggregation tended to break down, and the pH had risen to 10.what is the likely explanation for this situation?
2. What physical and chemical treatments would you suggest to bring the soil described in question 1back to its original state of productivity?

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MODULE 3

UNIT 1 WASTE SOURCES, EFFECTS AND MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Wastes are produced from different activities such as household activities, agricultural activities industrial activities, hospitals, educational institutions, mining operations, and so on. There sources general different types of wastes, many of which are hazardous in nature and can cause soil degradation.

2.0 OBJECTIVES

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

- understand the meaning and different sources of waste
- know the effects of waste on soil
- know the prevention and possible solutions for waste management.

3.1.1 Sources of Waste

Wastes produced from different sources, are classified as follows:

- **Municipal solid waste**

The wastes collected from the residential houses, markets, streets and other places mostly in the urban areas and disposed of by municipal bodies are called municipal solid wastes (MSW). In general, the urban solid wastes are called refuse. The Municipal solid wastes are a mixture of paper, plastic, clothes, metals, glass, organic matter etc. generated from households, commercial establishments and markets.

The proportions of different constituents vary from season to season and place to place depending on the life style, food habits, standard of living and the extent of commercial and industrial activities in the area. Municipal solid wastes are collected locally and the amount collected depends upon the size and consumption of the population.

- **Industrial wastes**

Industrial wastes are released from chemical plants, paint industries, cement factories, power plants, metallurgical plants, mining operations, textile industries, food processing industries petroleum industries and thermal power plants. These industries produce different types of waste products. Industrial solid wastes can be classified into two groups.

Non-hazardous wastes

These wastes are produced from food processing plants, cotton mills, paper mills, sugar mills and textile industries.

Hazardous wastes

Hazardous wastes are generated by nearly every industry. Metals, chemical, drugs, lather, pulp, electroplating, dye, rubber are some of important examples. Liquid Industrial waste that runs into a stream from a factory can kill the aquatic fauna and also cause health problems for humans.

- **Commercial wastes**

With the advancement of modern cities, industries and automobiles, huge amount of wastes are generated daily. These include markets, roads, buildings, hotels, commercial complexes, hostels, auto workshops, printing press etc. Hospitals, nursing homes and medical institutes also release tremendous amount of wastes which are hazardous and are much toxic in nature. Many chemicals and disposable items are also produced from these units. These wastes are dumped in inhabited areas which pose much danger to human health and life and cause several types of infectious diseases. Apart from wastes, generated from the above sources, there are certain wastes produced from mining activities and radioactive substances that cause much damage to the society and environment.

Mining
The wastes generated by mining activities disturb the physical, chemical and biological features of the land and atmosphere. The wastes include the overburden material, mine tailings (the waste left after ore has been extracted from rock), harmful gases released by blasting etc.

Radioactive substances
Although every precaution is taken in the functioning and maintenance of nuclear reactors, yet it has been observed that measurable amount of radioactive waste material escapes into the environment. Other sources of radioactive wastes are from mining of radioactive substances and atomic explosion etc.

Bio-medical wastes
Wastes, which are produced from the hospitals, medical centres and nursing homes are called bio-medical wastes. These wastes are highly infectious which include used bandages, infected needles, animal remains, cultures, amputated body organs, dead human foetuses, wastes of surgery and other materials from biological research centres. Pharmacies discard out-dated and unused drugs; testing laboratories dispose of chemical wastes which are hazardous in the environment.

- **Agricultural wastes**

Agricultural areas produce plants and animals wastes. Excess use of fertilizer, pesticides and other chemicals used in agriculture and the wastes formed from these cause land and water pollution. They also contaminate the soil. Among pesticides chlorinated hydrocarbons, DDT, BHC, endrin, dieldrin, lindane, parathion, malathion and endosulphon are important which are absorbed by the soil and contaminate crops grown in the soil. Other agriculture wastes are produced from sugar factories, tobacco processing units, slaughter houses, livestock, poultry etc.

3.1.2 Effects of Waste

From time immemorial, waste disposal has been a problem, and after industrialization the problem has only compounded. In many parts of world, trash was carried to the outskirts of cities and discarded in the open and various waste disposal methods have been devised; like compost, burning, landfill, biological reprocessing etc. which may have some impacts on the soil properties depending on the sources of the waste.

1. Chemical pesticides, herbicides and agrochemicals used to control pests, diseases and weeds normally contaminate the soil and can persist for years. As a result, it gradually alters the soil

microbial activities and soil chemistry, depleting soil fertility by killing soil microorganisms. Reports determine that millions of fertile soils are lost annually because of the use of synthetic fertilizers, pesticides, and herbicides combined with other farm practices.

2. Precipitation that infiltrates through the municipal solid waste leach the constituents from the decomposed waste mass and while moving down causes the subsurface soil to be contaminated by organic and inorganic solutes. As leachate percolates into the soil, it migrates contaminants into the soil and affects soil stability and strength.
3. When untreated effluents are discharged directly into water bodies, hey disrupt the physic chemical properties of the soil.
4. Direct use of industrial effluents may raise problems like salinity, alkalinity or toxicity in the soils as a result of long-term irrigation with such waters.

3.1.3 Prevention/Possible Solution

Basically, there are two approaches to addressing the challenges of hazardous wastes:

1. Waste Management: Minimising the Impact
Waste management is based on the premise that a high volume of waste is the unavoidable result of our modern lifestyle and of economic development. The objective is therefore to manage waste and minimize its impact. Waste-management strategies include burying or incinerating waste or exporting it to some other state or country.

2. Waste Prevention: Minimising the Volume
Preventing waste is a kind of "front-end" approach; it views waste either as material that should not be created in the first place or as a potential resource that can be used as raw material for another process. The fundamental objectives of this approach are to reduce the use of new raw materials and energy and to recycle waste products back into usable resources.

However, the waste-prevention approach should have the following hierarchy of goals:

1. Reduce waste and pollution.
2. Reuse as many things as possible.
3. Recycle and compost as much waste as possible.
4. Chemically or biologically treat or incinerate waste that can't be reduced, reused, recycled, or composted.

5. After the first four goals have been met, bury what is left in state-of-the-art landfills or above-ground vaults.

4.0 CONCLUSION

Waste is the useless by product of human activities which physically contains the same substance that are available in the useful product. It can be classified broadly into three main types according to their physical states; these are liquid, solid and gaseous waste. Some of the wastes are hazardous while others are non-hazardous. However, inappropriate management of the waste may lead to soil degradation.

5.0 SUMMARY

In this unit we have learnt that:

- Basically three types of wastes generated are classified based on their chemical, biological and physical characteristics as: Solid, liquid and gaseous wastes.
- When effluents of industries are disposed on soil, because of their high BOD, they may develop unaerobic conditions thereby affecting soil quality.
- The concept of waste hierarchy management was identified as the best, which consider the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimisation.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the term “waste” and it sources.
2. Differentiate between waste management and waste prevention.

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UNIT 2 CLIMATE CHANGE: EFFECTS AND MITIGATION

CONTENTS

1.0 INTRODUCTION

Human activities are increasing the atmospheric concentrations of greenhouse gases - which tend to warm the atmosphere - and, in some regions, aerosols - which tend to cool the atmosphere. potentially serious changes have been identified, including an increase in some regions in the incidence of extreme high-temperature events, floods, and droughts, with resultant consequences for fires, pest outbreaks, and ecosystem composition, structure, and functioning, including primary productivity. Climate change also may worsen soil degradation, which is related to more frequent and more severe droughts. Other than in tropical ecosystems, soil contains about twice as much organic carbon as above- ground vegetation. There is growing realisation of the role of soil, in particular peat, as a store of carbon and its role in managing terrestrial fluxes of atmospheric carbon dioxide (CO_2).

2.0 OBJECTIVES

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

- know the concept of climate change and its effects
- understand the mitigation strategies.

3.0 MAIN CONTENT

3.1.1 Effects of Climate Change

Agriculture and Food Security

- The response of crop yields to climate change varies widely, depending on the species, cultivar, soil conditions, treatment of CO_2 direct effects, etc.
- Degradation of soil and water resources is one of the major future challenges for global agriculture.

Water resources

- There are apparent trends in stream flow volumes - increases and decreases - in many regions. Peak stream flow will move from spring to winter in many areas because with warming a greater proportion of winter precip falls as rain.
- Flood magnitude and frequency are likely to increase in most regions as a consequence of increase in the frequency of heavy precip events.
- Climate change challenges existing water resources management by adding uncertainty.

3.1.2 Mitigation

Options to Reduce Emissions and Enhance Sinks of Green House Gas:

- Human activities are directly increasing the atmospheric concentrations of several greenhouse gases, especially CO2, CH4, halocarbons, sulfur hexafluoride (SF6), and nitrous oxide (N2O).
- CO2 is the most important of these gases, followed by CH4.
- Human activities also indirectly affect concentrations of water vapor and ozone.
- Significant reductions in net greenhouse gas emissions are technically possible and can be economically feasible.

Agriculture, rangelands, and forestry

- Beyond the use of biomass fuels to displace fossil fuels, the management of forests, agricultural lands, and rangelands can play an important role in reducing current emissions of CO2, CH4, and N2O and in enhancing carbon sinks.
- A number of measures could conserve and sequester substantial amounts of carbon (approximately 60-90 Gt in the forestry sector alone) over the next 50 years.

Land use and management measures include;

- Sustaining existing forest cover
- Slowing deforestation
- Regenerating natural forests
- Establishing tree populations
- Promoting agroforestry
- Altering management of agricultural soils and rangelands
- Improving efficiency of fertilizer use
- Restoring degraded agricultural lands and rangelands
- Recovering CH_4 from stored manure
- Improving the diet quality of ruminants

4.0 CONCLUSION

While climate is a key soil forming factor and governs a large number of pedogenic processes, soil can also influence global climate. Some soils store huge amounts of organic carbon and large releases of greenhouse gases from these could have a dramatic effect on global climate. Unless suitable land management procedures are implemented, increased and more severe droughts will cause soil water retention mechanisms to collapse, leading to the onset of erosion, desertification and increased risk of flooding

5.0 SUMMARY

In this unit we have learnt that:

- Greenhouse gas (GHG) emission is mostly influenced by human activities.
- Drought, flood magnitude and frequency are likely to increase in most regions as a consequence of decrease and increase in the frequency of precipitation events.
- Part of the effective mitigation measures include; the management of forests, agricultural lands, and rangelands can play an important role in reducing current emissions of CO_2, CH_4, and N_2O and in enhancing carbon sinks.

6.0 TUTOR-MARKED ASSIGNMENT

1. Carbon dioxide and other greenhouse gases are responsible for global warming. Discuss.
2. What are the effects of climate change on soil degradation? List ten (10) mitigation measures.

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UNIT 3 DEFORESTATION: CAUSES, EFFECTS, PREVENTION AND CONTROL

CONTENTS

1.0 INTRODUCTION

Deforestation is the permanent destruction of forests in order to make the land available for other uses. An estimated 18 million acres (7.3 million hectares) of forest, which is roughly the size of the country of Panama, are lost each year, according to the United Nations' Food and Agriculture Organisation (FAO).Forests cover 31% of the land area on our planet. They help people thrive and survive by, for example, purifying water and air and also play a critical role in mitigating climate change because they act as a carbon sink—soaking up carbon dioxide that would otherwise be free in the atmosphere and contribute to ongoing changes in climate patterns.

2.0 OBJECTIVES

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

- know the meaning of deforestation
- differentiate between deforestation, afforestation and reforestation.
- know the major causes of deforestation and their effects on soil
- know measures taken to control deforestation.

3.0 MAIN CONTENT

3.1 Deforestation

3.1.1 Causes of Deforestation

The threat in the benefits derived from forest are manifesting in the form of deforestation and forest degradation. The main cause of deforestation is agriculture (poorly planned infrastructure is emerging as a big threat too) and the main cause of forest degradation is illegal logging, and sometimes it may happen quickly such as when a fire sweeps through the landscape. Causes of deforestation include;

Fuel wood harvesting
Wood is still a popular fuel choice for cooking and heating around the world, and about half of the illegal removal of timber from forests is thought to be for use as fuel wood.

Conversion to agriculture
Expanding agriculture, due to an increased population and shifts in diet, is responsible for most of the world's deforestation. As the human population continues to grow, there is an obvious need for more food. In addition, agricultural products, such as soy and palm oil, are used in an ever-increasing list of products, from animal feed to lipstick and biofuels. Rising demand has created incentives to convert forests to farmland and ranch land. Once a forest is lost to agriculture, it is usually gone forever—along with many of the plants and animals that once lived there.

Fires
Fires are a natural and beneficial element of many forest landscapes, but they are problematic when they occur in the wrong place, at the wrong frequency or at the wrong severity. Each year, millions of acres of forest around the world are destroyed or degraded by fire. The same amount is lost to logging and agriculture combined. Fire is often used as a way to clear land for other uses such as planting crops. These fires not only alter the structure and composition of forests, but they can open up forests to invasive species, threaten biological diversity, alter water cycles and soil fertility, and destroy the livelihoods of the people who live in and around the forests.

Grazing
It is a well-established fact that over grazing leads to a gradual change in vegetation from derived savannah to Sudan savannah as these animals feed on tree seedlings especially in the dry season when there is little

grass to sustain them. These animals also feed on tree seedlings and branches of mature trees, thereby leading to deforestation (NEST, 1992).

Urbanisation and industrialisation
Increase in population has led to several houses and infrastructure springing up everywhere, thereby threatening the forests (NEST, 1992). For instance, Nigeria had a forest area of about 60 million hectares in 1897, but after 100 years the country had only about 9.6 million hectares which represent a loss of 50 million hectares in 100 years (Carty, 1992).

3.1.2 Effects of Deforestation

Forests are more than just a collection of trees and other plants—they are integrated ecosystems and home to some of the most diverse life on Earth. They are also major players in the carbon and water cycles that make life possible. When forests are lost or degraded, their destruction sets off a series of changes that affect life both locally and around the world.

Increased greenhouse gas emissions
Forests are carbon sinks and, therefore, help to mitigate the emission of carbon dioxide and other greenhouse gases. Tropical forests alone hold more than 228 to 247 gigatons of carbon, which is more than seven times the amount emitted each year by human activities. But when forests are cut, burned or otherwise removed they emit carbon instead of absorb carbon. Deforestation and forest degradation are responsible for around 15% of all greenhouse gas emissions. These greenhouse gas emissions contribute to rising temperatures, changes in patterns of weather and water, and an increased frequency of extreme weather events. Changes in climate can affect forest-dwelling creatures by altering their habitats and decreasing availability of food and water.

Depletion of soil and water resources
It has been established that most fishes and other aquatic animals breed under the root of some aquatic trees. With deforestation, these trees are few, therefore the population of these animals is reduced. Deforestation equally triggers the loss of several tones of soil from soil erosion leading to reduced food production, creation of gullies and forced migration.

Increased soil erosion
Without trees to anchor fertile soil, erosion can occur and sweep the land into rivers. The agricultural plants that often replace the trees cannot hold onto the soil. Many of these plants—such as coffee, cotton, palm oil, soybean and wheat—can actually exacerbate soil erosion. Scientists have estimated that a third of the world's arable land has been lost through soil erosion and other types of degradation. And as fertile soil

washes away, agricultural producers move on, clearing more forest and continuing the cycle of soil loss.

3.1.3 Control/Prevention of Deforestation

To stop deforestation, several approaches are adopted which includes;

Creation of forest reserves
These are areas delineated and gazetted by government and activities, such as taking and selling of forest produce without license, destruction of forest estate, destruction of water ways as well as kindling of fire without consent are prohibited.

Commencement of in-situ conservation processes
For biodiversity through the creation of strict nature reserves, National Parks, Biosphere Reserves, Investigation plots for natural regeneration, some sanctuaries, fish parks, wetland, conservation areas etc.

Legislation
Many laws and edicts have been enacted to control and enhance forest conservation. The problem is that, these laws have not been properly enforced to serve as a deterrent to defaulters.

Rainforest management
Many techniques have been utilised to manage the rainforest. These methods include; enrichment planting, tropical shelterwood system, taungya system, plantation establishment, malayan uniform system etc.

Afforestation programmes
Afforestation is the process of planting trees, or sowing seeds, in a barren land devoid of any trees to create a forest. Many afforestation programmes have been carried out in Nigeria over the years. However, there are very few mature forest plantations to provide fuel wood and sawn timber. Also, very few wood based companies have plantations of their own. Even the annual tree planting campaign, which was started by the Forestry Association of Nigeria in order to create awareness for tree planting has been hijacked by politicians.

Promoting sustainable alternative source of energy
Humans have used forests for fuel for thousands of years, and 2.6 billion people today still use biomass—mainly wood and charcoal—for cooking. The need to promote bioenergy from scrap wood, oil and fats, sugar and starch crops, residues and wastes, and even algae to reduce reliance on forests and decrease greenhouse gas emissions will help in controlling deforestation.

4.0 CONCLUSION

Deforestation is associated with felling of wood for fuel, commercial logging and activities associated with temporary removal of forest cover such as slash and burn technique as well as clearing of forest for grazing or ranching. Part of is consequences include; Greenhouse gas emissions, depletion of soil and water resources and soil degradation.

5.0 SUMMARY

In this unit we have learnt that:

1. Deforestation results from the removal of trees without sufficient replacement.
2. Many specific terms such as forest decline, forest fragmentation and degradation, loss of forest cover and land- use conversions, should also be used for deforestation.
3. Deforestation has tremendously threatened depleted or endangered biodiversity of the forest ecosystem. It also has negative ecological, genetic and socio-economic impact on the environment.
4. Awareness, legislation, enforcement of laws enacted, are the key measures in controlling deforestation.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the consequences of deforestation and how they should be tackled.
2. Among the methods of controlling deforestation, which one is the most effective? And why?

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UNIT 4 DESERTIFICATION: CAUSES, EFFECTS, PREVENTION AND CONTROL

CONTENTS

1.0 INTRODUCTION

Desertification defined as the spread of desert like conditions as a result of a combination of climatic fluctuations and human impacts, is a form of land degradation that occurs in and around the world's dry lands. Considerable debate surrounds the speed, nature, and causes of desertification, but it undoubtedly has a series of health implications. In defining desertification, it is important to consider the aspects of; climate and human activities as the causal factors, vulnerability of arid and semi-arid lands and land degradation and loss of biodiversity consequences. The features of desertification process include; impoverishment of vegetative cover, reduced quantity, available and accessible of soil moisture, deterioration of the texture, structure, nutrient status of soil ,reduced biodiversity and presence of more xeric biota and Increase soil erosion.

1.0 OBJECTIVES

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

- know the concept of desertification
- understand the causes of desertification to be a combination of climate and human impacts
- know that, due to desertification, the carbon sequestration ability of vegetation and soil is greatly lost making carbon to be increased in the atmosphere thereby aggravating global warming
- know the different strategies to be used in remediating the menace of desertification.

3.0 MAIN CONTENT

3.1 Desertification

3.1.1 Causes of Desertification

The causes of desertification are numerous and complex, but like many other issues of environmental degradation, they are basically the resultant interactions of climatic influence and human activities in the environment. The causes include;

Climatic variability

Climatic variability is a major driver of many environmental degradation phenomena. Alteration of climatic conditions leads to naturally occurring phenomena of drought and desertification. There has been increasing level of greenhouse gases causing global warming which in turn increase the variability of climate conditions. This alteration in the climatic conditions has manifested as follows:

i. A decrease in the amount of rainfall in drylands making arid and sem-arid lands more vulnerable to desertification.
ii. High temperatures, combined with low rainfall which would lead to the drying up of water resources -drought.
iii. Poor growth of vegetation leading to the formation of a desert-like condition.

Anthropogenic activities
The anthropogenic factors have been the major cause of desertification just like many ecological degradation problems. This can be viewed as exploitation of resources from ―non-ideal lands‖, over exploitation of land resources, unsustainable acts when exploiting, and none replacement of exploited resources or not allowing sufficient time for natural regeneration of exploited resources. The following human activities can cause desertification:

Extensive cultivation
Expansion of agricultural land to meet up with the food requirements of the increasing population has led to the degradation of land. New lands are cleared of trees and other vegetation to establish agricultural croplands in the dry land, many of such lands are unable of recuperation, and hence desertification sets in.

Overgrasing

In the Sudan and the Sahel zones, which carry most of the livestock population, nomadic herdsmen graze their livestock throughout the area and are constantly in search of suitable pastures. Additional pressure is also on these natural rangelands by livestock from neighboring countries. Overgrazing removes the vegetation cover that protects soil from erosion (UNCCD, 2011) and degrades natural vegetation that leads to desertification and decrease in the quality of rangelands

Cultivation of marginal land

Cultivation of marginal areas is one of the causes of desertification. Marginal lands are areas that are unable to support permanent or intensive agriculture which could be easily degraded following cultivation. During the periods of high rainfall, people tend to extend farming activities into the marginal areas. When these periods of high precipitation is succeeded by abrupt dry periods, the exposed land with very little vegetal cover is prone to wind erosion and desertification may set in which could be irreversible except through carefully planned rehabilitation programme

Bush burning

Slash and burn practice in agriculture and fire- hunting is a major cause of desertification in northern Nigeria. Owing to the low relative humidity in the area coupled with very dry harmattan wind, there is always a high incidence of bush fires every dry season. When this occurs too frequently, the vegetation may not regenerate; the soil is exposed to erosion and become degraded.

Fuel wood extraction

Due to socio-economic status of the people inhabiting Nigeria dry land, felling of tree for fuel wood will continue increasing if alternative sources of energy in the sudano-sahelian zone are not provided. The demand for fuel wood causes the removal of trees, shrubs, herbaceous plants and grass cover from the fragile land, accelerating the degradation of the soil to desert-like conditions. In Nigeria, more than 70% of the nation’s population depends on fuel wood. Katsina alone, a northern state, has its over 90% energy from fuel wood. In Kano City, 75,000 tonnes of fuel wood are brought in by lorry and donkey within a radius of 20km, which leads to denuding of the woodland.

Faulty irrigation management

Irrigation system is a common practice in northern Nigeria. Many farmers lack adequate skills in proper designing and management of irrigation system which has resulted into desert-like condition of many irrigated farmlands as a result of water logging and salinization.

Urbanisation

Rapid economic growth and urbanisation has been identified as one of the causal factors of desertification. The problem is more severe and complicated in developing world. Clearing of lands to accommodate the increasing population and accommodate the necessary infrastructure in northern is commonly done without adequate environmental consideration; this has led to the removal of vegetation cover in the area and as such, making the area desertified. Urbanisation in Kano City for instance has been estimated to be increasing rapidly at the rate of between 5 to 10% per annum. .At least, 20,000 ha of land are cleared annually for construction.

3.1.2 Effects of Desertification

Geo-chemical effects

Not only is biological environment is negatively impacted by desertification; the geological and chemical environments are as well impinged. The geo-chemical effects include:

Global warming

Global warming is defined as an increase in earth's mean global temperature. A part of earth's outgoing infrared radiation is retained by several trace gases in the atmosphere whose concentrations have been increased because of human activities. Vegetation and soil play a great role in sequestrating carbon; an important greenhouse gas. When desertification occurs, the carbon sequestration ability of vegetation and soil is greatly lost making carbon to be increased in the atmosphere thereby aggravating global warming.

Increased erosion

Soil erosion is the movement and transport of soil by various agents particularly water and wind leading to soil loss. Impoverishment of soil's natural vegetation cover has been a primary cause of soil erosion. When land is deforested, the soil anchorage provided by trees and other plants is lost and the soil is rapidly eroded. Because of the nature of desertification prone area, soil erosion by wind occurs but erosion by water is more disastrous during the unusual heavy rainfall.

Soil Salinisation

Soil salinity is an important chemical degradation problem facing agriculture. Agricultural sustainability in northern Nigeria is majorly by irrigation system which again predisposes such inland areas to saline soils and reduced crop productivity if not properly managed.

Reduced agricultural productivity and food insecurity

Agriculture is the economic mainstay of the majority of households in Nigeria and is a significant sector of Nigeria's economy. Food security in its most basic form is the access of all people to the food needed for healthy life at all times. Factors that affect soil quality affect agricultural productivity also and indirectly on food supply. Loss of soil structure and cohesion, soil crusting, soil compaction and soil erosion especially in arable lands has been enumerated as consequences of desertification which also reduce agricultural output, hence food insecurity.

3.1.3 Preventing/ Controlling Desertification

Solution to the problem of desertification must target all aspects that relate to the problem. Though some desert conditions are irreversible even if all anthropogenic causes are stopped now, but some are reversible. Some of the remedies to desertification include:

Awareness

Raising awareness of desertification at local, national and global level is key to remedying drought and desertification. It is probably the cheapest means in combating desertification because it serves as a preventive measure. Awareness will provide people with the understanding of the causes and consequences of the phenomena so as to stop all possible causes and encourage actions that would remedy some of the consequences and prevent further degradation of soil.

Protection of marginal lands

Due to the incapability of marginal lands to support permanent or intensive agriculture, there is need for proper evaluation of such lands with government policy and enforcement aimed at protecting them from any activities that is capable of denuding its vegetation cover.

Planting and protection of indigenous tree and shrub species
Increasing the area of conspicuous vegetation into desertifying lands is vital in managing desertification. This could be done through intensive and technologically supportive reclamation, by planting and establishing indigenous trees and vegetation known to the area. Planting of trees coupled with avoided felling should be embraced in arid and semi-arid zones until if possible a forest zone is attained. Planting of tress helps in

i. Soil stability
ii. Protection of soil from erosion
iii. Retention of soil moisture and nutrients
Iv. Carbon sequestration

Sustainable agricultural practices
Agroforestry is a form of farming system that plays an extremely important role in the land management of semi-arid and arid zones. Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines agricultural and forestry techniques to create more diverse, productive, profitable, healthy, and sustainable land-use system. Grazing systems should be improved from denuding the natural rangelands whose consumption will lead to aridity condition hence establishment of new pastures for grazing by livestock should be ensured. All water to be used for irrigation should be examined to be devoid of level of salt that could result in salt accumulation, as well as ensuring a good drainage system.

Use of alternative source of energy
Feeling of the few trees and shrubs in desert-prone areas for fuel wood can be reduced through the development of sustainable alternative energy sources such as biofuel. This will not only conserve forest resources but will reduce environmental pollution.

4.0 CONCLUSION

Desertification is a global environmental problem of arid and semi-arid regions. The phenomena integrate climatic elements with human activities in transforming productive land, into an impoverished area generally refers to as desert. Impacts of drought and desertification are felt in all aspects of the environment and human livelihood. Remedies to these problems involves awareness, protection of marginal lands, planting of indigenous tree and shrub species, sustainable agricultural practices and use of alternative energy source.

5.0 SUMMARY

In this unit we have learnt that:

1. Desertification can lead to global warming, which ultimately result in soil degradation.
2. Human influence and climatic variables are responsible for deforestation.
3. Legislation with enforcement will help in preventing/controlling desertification.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the Geo-chemical effects of desertification
2. What is sustainable agriculture? Explain how it is going to be used to remediate desertification.

7.0 REFERENCES/FURTHER READING

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UNIT 5 LAND RECLAMATION TECHNOLOGIES

CONTENTS

1.0 INTRODUCTION

Land reclamation is the process of improving lands to make them suitable for a more intensive use. Reclamation efforts may be concerned with the improvement of rainfall-deficient areas by irrigation, the removal of detrimental constituents from salty or alkali lands, the diking and draining of tidal marshes, the smoothing and revegetation of strip-mine spoil areas, and similar activities. Land reclamation is performed with the view of improving soil productivity and keeping viable farming, as well as ensuring guaranteed agricultural production based on maintaining and improving land fertility, as well as creating necessary conditions for drawing of unused and low-yield lands into agricultural production, formation of rational pattern of lands, integrated forest management, and conservation, reproduction, and efficient use of natural resources.

5.1 OBJECTIVES

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

- know the conditions for land reclamation
- understand the techniques to be used in reclaiming degraded lands
- know how to manage the lands already reclaimed.

3.0 MAIN CONTENT

3.1 Land Reclamation Technologies

3.1.1 Types of Land Reclamation

Land reclamation contributes to the maintenance and improvement of soil fertility, growth of crop capacity, rise of farming sustainability, mitigation of the effect of climate and weather fluctuations on production capacity. The scale of land reclamation expands; however, at the current stage the main focus is on enhancing its efficiency. Three key land reclamation types are discussed as follows:

- Lands that are under adverse water regime conditions manifested in either excess moisture or its shortage as compared to the quantity that is deemed sufficient for efficient use of the area for economic purposes.
- Lands that are under adverse physical and chemical properties of soil (heavy clay and muddy soils, saline, with higher acidity, etc.).
- Lands that are liable to damaging physical impacts, i.e. water and wind erosion.

3.1.2 Techniques of Land Reclamation

- **Irrigation**

The reclamation intended to eliminate water shortage in the soil of agricultural fields is referred to as irrigation. The extent to which land is improved by irrigation is related to the aridity of the land in its natural state. Land reclamation by irrigation is, however, not limited to desert regions. Much of the land irrigated in humid areas throughout the world is used for the production of paddy rice, although irrigation of vegetable crops, usually with overhead sprinkler systems, also is practised on a considerable acreage.

- **Drainage**: The reclamation oriented to remove excessive moisture from an area is called drainage reclamation. It is used, in addition to agriculture, in public utility, industrial, and road construction, peat extraction, when carrying out curative measures on swamp areas (wetlands), and other land development activities. The first requirement of a drainage project is an outlet for the water. One of the most common means of providing this outlet is to dig a ditch from the swampy area to a river, sea, or other natural body of water. The size of the ditch is determined by the amount of water to be carried and the gradient of slope along the ditch. The “topography” of the land, the amount of water to be removed in a given time (called the drainage coefficient), and the distribution and nature of underlying strata are factors determining the design of the drainage systems for moving the water from the land to the outlet.

Of particular importance is the "permeability", or ability to transmit water, of the soil and underlying strata. If the soil and underlying strata have a low permeability, a quality frequently found in clay soils, the excess water must be removed by surface flow. This may require regularly spaced small ditches throughout the area to be drained and a land forming or grading operation to provide slopes toward the field ditches and to eliminate low spots between ditches. If the soil is permeable, the excess water may be removed through "tile" line installed beneath the surface of the soil. The tiles are traditionally made of fired clay or concrete, although corrugated plastic tubing is also commonly used. The spacing of the tile lines is governed by the permeability of the soil. The more permeable the soil, the farther apart the tile lines. The tile lines may be installed in a regular pattern in large wet areas or in a random pattern where critical wetness is confined to scattered spots in the area. Tile drains have the advantage over open ditch drains in that farm operations can be conducted across the tile lines, making it possible to use larger and more efficient fields, with no loss of land occupied by ditches.

Occasionally, underground drains are constructed without use of tile by drawing a bullet-shaped tool through the soil at a depth of 18–36 inches (46–91 cm). This tool leaves a "channel" through the subsoil that may serve the same drainage function as a tile line. The practice of forming unlined underground drains is called mole drainage. After a period of time, depending upon the stability of the soil, the unlined channels collapse and the mole drainage operation must be repeated. With the development of low-cost flexible plastic materials, devices for lining mole drains with perforated plastic liners to increase the life of the drains were developed.

If a permeable strata such as gravel underlies the area to be drained, widely spaced open ditches dug into the permeable strata usually provide effective drainage. Frequently, poorly drained swampy areas are occupied by soils very high in organic matter, called "peats" and mucks. When these organic soils are drained, the improved soil aeration brings about an increase in the rate of oxidation of the organic material, resulting in a loss of the soil material itself. This leads to a "subsidence" of the land surface, and, in some cases, the land surface may sink several feet. Subsidence of drained organic soils is more rapid in warm climates than in cooler areas.

Some areas are too wet for crop production because of recurrent flooding from adjacent rivers and creeks. Reclamation of this type of "wetland" is usually affected by building "levees" along the stream to keep it confined in its channel. If necessary, excess water originating in the protected area is lifted over the levee by pumps.

- **Reclamation techniques for salt-affected soils**

The salts found in soils are generally the chlorides, carbonates, bicarbonates, and sulfates of sodium, with lesser amounts of potassium, magnesium, and calcium salts. The reclamation of salt-affected soils follows the exact reverse of the process by which they are formed. The first step is to improve the drainage so that upward movement of ground water to the soil surface ceases and water applied to the surface can move down through the soil profile. Then fresh no saline water is applied to the surface by irrigation. This fresh water washes out the excess salts, which are carried away in the drainage water. In the case of sodic soils, amendments that will supply a fresh source of soluble calcium to replace the sodium adsorbed by the soil are added. and leaching is carried out until the replaced sodium is removed. Gypsum (calcium sulfate) is the most common amendment used to supply calcium for the reclamation of sodic soil. Deep tillage to break up the horizons high in adsorbed sodium is a common technique used for the reclamation of this soil.

- **Reclamation techniques for eroded soils**

Where soil erosion is severe, a land area may be denuded of topsoil and interlaced with a dendritic, or branched, system of steep-sided watercourses called gullies. These areas are generally devoid of vegetation, and sediment eroded from them may menace lower-lying lands or water retention structures. In humid regions these eroded areas are usually reclaimed by reforestation accompanied by exclusion of livestock from the area. If the gullied area is not large and topographic conditions permit, a diversion ditch to prevent runoff from higher lying areas from entering the gullied area may hasten the reclamation process. Native plant invasion and succession may vegetate eroded areas if they can be protected from the cause of the accelerated erosion. Where the subsoil material is friable and fertile, the land may be graded to obliterate the gullies and permit production of pasture or other close growing crops.

3.1.3 Management of Reclaimed Soils

Once salt-affected soils have been reclaimed, prudent management's eps must be taken to be certain that the soils remain productive. For example surveillance of the EC and SAR and trace elements composition of the irrigation water is essential. Management adjustment is needed to accommodate any change in water quality that could affect the soil. The number and timing of irrigation episodes tend to determine the balance of salts entering and leaving the soil. Likewise, the maintenance of good internal drainage is essential for the removal of excess salts. Steps should be taken to monitor appropriate chemical characteristics of the soils, such as pH EC, and SAR, as well as specific levels of such elements as boron, chlorine, molybdenum and selenium that could lead to chemical toxicities. These measurements will help determine the need for subsequent remedial practices and/or chemicals. Crop and soil fertility management for satisfactory yield levels is essential to maintain the overall quality of salt-affected soils.

1.0 CONCLUSION

Land reclamation is the recovery of land from wetlands or other water bodies, and the restoration of productivity or use of lands that have been degraded by human activity or impaired by natural phenomena. Reclamation can be a tool in both preventing erosion and can also be used to repair land that has already been eroded.

5.0 SUMMARY

In this unit we have learnt that:

- The reclamation oriented to remove excessive moisture from an area is called drainage reclamation.
- The reclamation intended to eliminate water shortage in the soil of agricultural fields is referred to as irrigation.
- Reclamation of lands with adverse physical properties is aimed at improving soil aeration, as well as increasing its porosity and permeability.
- Reclamation of lands with adverse chemical properties consists in removing harmful salts by leaching, lowering soil acidity by applying lime, raising soil nutrient-supplying power by distributing fertilizers, and introduction of proper crop rotation with higher ratio of grass.

6.0 TUTOR-MARKED ASSIGNMENT

1. How do you manage a reclaimed soil?
2. What are the advantages of using gypsum ($CaSO_4 .2H_20$) in the reclamation of a sodic soil? Show the chemical reaction that takes place.

7.0 REFERENCES/FURTHER READING

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