COURSE CONTENT

COURSE

Course code: MCB 424

Course title: Soil Microbiology

Course unit: 3 Units

Course status: Compulsory

COURSE DURATION

Three hours per week for 15 weeks (45 hours)

LECTURERS DATA

Name of the lecturer: Dr OB Akpor

Qualifications obtained: B.Sc, M.Sc, PhD

Department: Biological Sciences

College: Science and Engineering

E-mail: akpor.oghenerobor@lmu.edu.ng

Office Location: Room 51/A305

Consultation Hours: 12.00 noon – 2.00 pm (Mon. to Fri.)

Name of the lecturer: Dr CO Adetunji

Qualifications obtained: B.Sc, M.Sc, PhD

Department: Biological Sciences

College: Science and Engineering

E-mail: adetunji.charles@lmu.edu.ng

Office location:

Consultation hours:

Name of the lecturer: Mr Dahunsi OS

Qualifications obtained: B.Sc, M.Sc

Department: Biological Sciences

College: Science and Engineering

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Office Location: Room 51/A304

Consultation Hours: 12.00 noon – 2.00 pm (Mon. to Fri.)

COURSE CONTENT

The course covers the following areas: microorganisms in soil, factors affecting distribution and activities of microflora in soils, role of soil microorganisms in decomposition of plant and animal matter, soil fertility and cycles of natural elements, mycorrhiza and plant nutrients supply, the terrestrial environments, the nature, chemical activities on soil microflora, nitrogen fixation, ecological relationships among soil pathogens, effects of pesticides on soil microorganisms

COURSE DESCRIPTION

Soil Microbiology as a course deals with soil is a medium for microbial growth, the relation of microbes to important mineral transformations in soil, importance of biological equilibrium and significance of soil microbes to environmental quality.

COURSE JUSTIFICATION

The course is important because the soil microbiologist is in a position to make important contributions not only knowledge of soil processes and plant growth but also to microbiology. A good knowledge of soil microbiology could help the graduate of microbiology to contribute in many ways to man's capacity to survive, by learning the activities of both beneficial and harmful microorganisms. A good knowledge of soil microbiology is essential to understanding agricultural and environmental sciences.

GENRAL COURSE OBJECTIVES

Upon completion of the course, students should be able to demonstrate basic knowledge of the following:

- The soil microbial community (macrofauna, mesofauna and microfauna) with emphasis on the factors affecting their distribution and activities
- Interactions between microorganisms and plants in soil
- Role of microorganisms in the biogeochemical cycle

COURSE REQUIREMENTS

For a student to derive maximum benefits from the course and for fast grasping of many of the concepts that will be taught. The course requires that the students be familiar with microbial ecology. The University policy on attendance will strictly apply. Also, students are expected to comport themselves and take course or class activities seriously.

METHOD OF GRADING

The grading for the course will be assessments of tests, term papers and examination.

S/N	**Grading**	**Score** (%)
1	Test	20
2	Term paper	10
3	Final Examination	70
	Total	**100**

COURSE DELIVERY STRATEGIES

Lecture, periodical assignments and practical

LECTURE CONTENTS AND DESCRIPTIONS

WEEKS	**LECTURE TOPICS**	**LECTURER**
1	Introduction to soil microbiology	Dr Akpor
2	Microbial populations and activities in soil	Mr Dahunsi
3	Soil microbial community_macrofauna	Mr Dahunsi
4	Soil microbial community_mesofauna	Mr Dahunsi
5	Soil microbial community _microfauna _protozoa and algae	Mr Dahunsi
6	Soil microbial community_microfauna_fungi and bacteria	Mr Dahunsi
7	Soil as a microbial habitat	Dr Akpor
8	Factors affecting distribution, activity and population of soil microorganisms	Dr Akpor
9	Microbial transformation of carbon	Dr Adetunji

10	Nitrogen cycle_nitrification, denitrification, ammonification, immobilization	Dr Adetunji
11	Microbial transformations of phosphorus and sulphur	Dr Adetunji
12	Microbial transformation of iron and manganese	Dr Adetunji
13	Microbial interactions in soil	Dr Akpor
14	Microbe-plant interactions (symbiotic nitrogen fixation, mycorrizae) and composting	Dr Akpor
15	Revision	Dr Adetunji

WEEK 1: INTRODUCTION TO SOIL MICROBIOLOGY

Objectives

The students at the end of the lectures for the week should be able to understand soil as a living environment and how microorganisms function in the soil ecosystem

Description

The concept of soil as a living environment will be explained. The functions and classification of soil organisms will also be discussed.

Study questions:

- Giving, specific examples, mention the five classes into which soil organisms are grouped
- Explain how human activities promote or inhibit growth of soil microorganisms
- Discuss five functions of microorganisms in a soil ecosystem six activities

WEEK 2: MICROBIAL POPULATIONS AND ACTIVITIES IN SOIL

Objectives

The students at the end of the lectures for the week should be able to understand the:

- The interactions between microbes and their physical, chemical and biological environment
- Microbial survival strategies

Description

Soil as an energy environment and microbial energy needs will be discussed. Also to be studied will be energy accessibility and microbial growth rates and activity levels in soils. The students will also be exposed to the concepts of growth and population maintenance strategies by microorganisms.

Study questions:

- In low environment, microbial biomass in soil is said to be largely inactive. Discuss
- Explain how microbial populations separate from each other to minimize competition
- How are soil microorganisms enumerated in the soil

WEEK 3: SOIL MICROBIAL COMMUNITY_MACROFAUNA

Objectives

The students at the end of the lectures for the week should be able to understand the:

- Explain the important roles of macrofauna in soil
- Identify the important macrofauna and explain how they assist in decomposition
- Identify the various ways of classifying macrofauna

Description

This section will expose the students to the macrofauna contribution to biomass, classification and types of macrofauna. In addition, students will be taught on how soil macrofauna are studied.

Study questions:

- What are some of the ways of classifying macrofauna
- Explain the relationship between size and number of macrofauna in soil
- How do macrofauna influence soil structure and accelerate the breakdown of organic matter in soil

WEEK 4: SOIL MICROBIAL COMMUNITY_MESOFAUNA

Objectives

After this lectures, the student should be able to:

- Name the important nematode groups and discuss their roles in the decomposition of organic matter decomposition
- Explain why nematodes are important to the soil microbial community and discuss how to extract them from soils

Description

In this contact, students will be exposed to the classification of nematode, nematode ecology and how to extract nematodes from soil

Study questions

- What are the major problems in the classification of nematodes?
- What is the rationale behind the way nematodes are classified?
- Explain why nematodes population are not static
- Why are nematodes in soil always smaller than nematodes in marine environments

WEEK 5: SOIL MICROBIAL COMMUNITY _MICROFAUNA _PROTOZOA AND ALGAE

Objectives

After this lectures, the student should be able to:

- Identify the classification of protozoa and give representative examples of each
- Discuss where protozoa are found in soil
- Explain the methods of studying protozoa
- Identify the major categories of algae
- Explain the contribution of algae to eutrophication

Description

In this contact, students will be exposed to the morphology, classification, ecology, feeding and growth of protozoa. Also, students will be taught the important algae groups in soil and their environmental

Study questions

- Name the major groups of protozoa and explain why their populations vary so much during the year
- Suggest reasons why protozoa cannot completely eliminate their prey
- What are the major groups of alae in soil and where are they found in the soil profile
- In what ways are soil algae different from other soil organisms

WEEK 6: SOIL MICROBIAL COMMUNITY _MICROFAUNA _FUNGI AND BACTERIA

Objectives

After this lectures, the student should be able to:

- Discuss the historical importance of fungi and bacteria
- List the major differences between fungi, bacteria
- Describe how the environment influence fungi and bacteria
- Explain the ecological roles of fungi and bacteria

Description

In this contact, students will be exposed to the classification of fungi and bacteria, habitats and environmental influences of fungi and bacteria and functional roles of fungi and bacteria in soil

Study questions

- What is the principal roles of fungi in the environment
- What is competitive saprophytic growth and why is it important
- How can you distinguish actinomycetes from fungi and bacteria
- What are the environmental conditions favourable for actinomycete growth
- What is the difference between autochthonous and allochthonous bacteria and where would you expect to find them

WEEK 7: SOIL AS A MICROBIAL HABITAT

Objectives

At the end of this week lectures, the students should be able to:

- Summarize the rudiments of soil classification, soil texture and composition
- Define soil quality and its relationship to soil microbiology
- Explain how microorganisms attach to soil and state how the arrangement of soil into aggregates and pores influences microbial populations
- Discuss how changes in extrinsic and intrinsic factors affect the distribution of soil microorganisms and control their populations

Description

The topic will expose the students to the principles of soil formation, morphology and classification, and the diversity and distribution of microorganisms

Study questions

- How microaggregates are stabilised differently than macroaggregates
- What physical, chemical or biological criteria might prevent soil from being quality soil?
- The steady-state soil ecosystem is sometimes compared to the daily conditions that occur at the corner of any large city. Discuss why their comparison is made
- Based on the environmental conditions existing around your home, what soil order do you predict is on it?

WEEK 8: FACTORS AFFECTING DISTRIBUTION, ACTIVITY AND POPULATION OF SOIL MICROORGANISMS

Objectives

At the end of this week lectures, the students should be able to:

- Describe the key three environmental factors affecting soil microorganisms
- Explain how soil moisture affects soil temperature and classify microorganisms based on their growth response to temperature
- Describe why excessively acidic or alkaline conditions impede microbial growth in soil

- Describe how soil microbiologists characterize microorganisms based on their response to pH
- Explain why soil water critically affects microbial life
- Describe the strategies that microorganisms use to tolerate water stress

Description

The lectures will expose the students to temperature relationships and their effect on microorganisms, redox potential and its effects on soil reactions and microbial life. The students will also be exposed to the concept of soil, soil water and microbial activity

Study questions

- Why is soil temperature important
- What controls soil temperature
- How does soil moisture affects soil temperature
- What is redox potential and why is it important
- Give reasons why soil water critically affects microbial life
- Describe the classes of microorganisms based on water stress response

WEEK 9: MICROBIAL TRANSFORMATION OF CARBON

Objectives

At the end of the lectures for this week, the student should be able to:

- Describe the reserviours of carbon on earth and discuss how biogeochemists use changes in those environments to assess carbon flow in the environment
- Identify the structures of the most important organic carbon compounds that plants contribute to the soil environment

Description

These lectures will expose the students to the tenets of microbial carbon cycling, carbon mineralization and growth, incorporation of organic carbon to the soil, soil organic matter and energy source for microorganisms

Study questions

- Discuss the functions and roles of soil organic matter
- What is humus and how is it characterised?
- What are the steps in the decomposition of cellulose?
- Why do cellulose and amylose decompose at different rates in soil?

WEEK 10: NITROGEN CYCLE_NITRIFICATION, DENITRIFICATION, AMMONIFICATION, IMMOBILIZATION

Objectives

At the end of these lectures, the students should be able to:

- Explain nitrification and its several types
- Identify the different bacteria involved in each step of nitrification
- Describe the physiology of nitrification
- Identify the most important mechanism by which ammonium is assimilated into soils
- Explain how C:N ratio controls whether mineralization or immobilization occurs
- Describe the different environments nd regulation of denitrification
- Discuss some of the environmental consequences of denitrification

Description

This section will expose the students to the concepts of chemoautotrophic nitrifiers, nitrification inhibitors and heterotrophic nitrification. The students will also be exposed to the principle of ammonium, ammonia assimilation and nitrogen availability. In addition, the students will also be exposed to environmental and reductive fates of nitrates

Study questions

- Explain the steps involved in nitrification
- What is heterotrophic nitrification
- What are the major environmental controls on nitrification in soil
- What will be the consequences of adding organic N with a very low C:N ratio to soil

- What is the pathway of denitrification
- How does denitrification differ from dissimilatory nitrate reduction to ammonium

WEEK 11: MICROBIAL TRANSFORMATIONS OF PHOSPHORUS AND SULPHUR

Objectives

After these lectures, the students should be able to:

- Draw the soil phosphorus and sulphur cycle
- List the important inorganic and organic forms of phosphorus in soil
- Describe the microbial activity makes phosphorus available for plant uptake
- Give examples of specific bacteria that carry out each type of sulphur transformations
- Describe the process of sulphur mineralization, assimilation, reduction and oxidation

Description

The student will be exposed to the different forms of phosphorus, redox reactions, phosphorus solubilisation, immobilization and mineralisation. The lectures will also expose the students to sulphur transformations, mineralisation, reduction and oxidation.

Study questions

- How do thermophilic temperatures help phosphorus availability
- What mechanisms do microorganisms use to solubilize phosphorus and make it more available

- What biological and chemical conditions could lead to phosphorus unavailability in soil
- What microbial population would you expect to see dominating in acidic sulphate soil
- How can Sulphur reduction contribute to pitting of iron pipes
- What type of metabolism does oxidation of hydrogen sulphide by *Thiobacillus* represent

WEEK 12: MICROBIAL TRANSFORMATION OF IRON AND MANGANESE

Objectives

At the end of the lectures, the students should be able to:

- Draw the diagrams of iron and manganese soil cycles
- Identify some examples of microbial groups that transform iron and manganese
- Explain why redox transformations in iron and manganese cycling are so important
- Discuss the important environmental consequences of iron and manganese transformations that affect agriculture

Description

The lectures will expose the students to the concepts of iron oxidation, reduction, availability and assimilation. The students will also be exposed to the concepts of manganese oxidation, availability and the environmental consequences of iron and manganese transformations

Study questions

- Under what conditions redox status of soil affect the type of electron acceptors microorganisms' use?
- Write a redox reaction showing coupled oxidation and reduction
- What are the environmental conditions and mechanisms by which iron and manganese clog drainage lines

WEEK 13: MICROBIAL INTERACTIONS IN SOIL

Objectives

- At the end of these lectures, the students should be able to:
- Describe seven critical microbial interactions: neutralism, amensalism, commensalism, mutualism, competition, parasitism and predation
- Define synergistic, protocooperative or symbiotic mutualistic interactions
- Discuss why parasitism and predation often involve soil microorganisms preying on larger organisms, such as nematodes
- Explain why microbial succession is a common ecological feature in soil

Description

The students will be exposed to the concepts of neutralism, commensalism, amensalism, mutualism, competition, predation and parasitism. The students will also be exposed to the principles of microbial succession

Study questions

- Why is microbial succession the norm, rather than the exception soil?
- In what ways is predation functionally important in soil
- What are the physiological characteristics of lichens that distinguish them from other organisms
- In what ways is predation functionally important in soil

WEEK 14: MICROBE-PLANT INTERACTIONS (SYMBIOTIC NITROGEN FIXATION & MYCORRIZAE) AND COMPOSTING

Objectives

At the end of the lectures for this week, the students should be able to:

- Describe several symbioses between bacteria and higher organisms that produce fixed nitrogen
- Identify the species of nodule-forming rhizobia and explain what a cross-inoculation group is
- Explain the role mycorrhizae play in plant mineral nutrition
- Describe the ecology and distribution of mycorrhizae in soil
- Summarize the benefits that mycorrhizae colonization to plants
- Describe what composting is and list five benefits in composting
- Explain what vermicomposting is

Description

The lectures will expose the students to legume-*Rhizobium* symbiosis, infection and nodule formation, nodule physiology, rhizobia inoculants and control of microbial pathogens. The students will also be exposed to the types of mycorrhizae, benefits of mycorrhizae, microbiology of composting and vermicomposting

Study questions

- Why is it sometimes necessary to use inoculum
- What conditions are necessary to successfully out compete indigenous rhizobia
- What components are necessary for an effective rhizobia inoculation program
- Under what conditions do you expect mycorrhizae to be of greatest importance in plant nutrition
- Discuss two mechanisms by which VAM affect phosphorus availability to plants
- What are the optimal environmental conditions for composting
- Why is aeration important to a well-functioning compost pile

WEEK 15: REVISION

READING LIST

- Alexander, M. 1997. Introduction to soil microbiology. John Wiley & Sons Inc. New York.
- Atlas R.M. and Bartha R. 1998. Microbial ecology: fundamentals and applications. 4th edition. Benjamin/Cummings Science Publishing, California
- Coyne M.S. 1999. Soil Microbiology: An Exploratory Approach. Delmar Publishers: New York
- Doetsch R.N and Cook T.M. Introduction to bacteria and their ecobiology, University Park Press, Baltimore
- Ingham R.E. 1994. Nematodes, *In* Methods of soil analysis, part 2: Microbiological and biochemical properties, Weaver R.W. (ed.), Soil Society of America
- Paul E.A. and Clark F.E. 1989. Soil microbiology and biochemistry. San Diego, CA: Academic Press
- Plaster, E.J. 1997. Soil Science and Management (3rd Ed.). Delmar Publishers, Inc., Albany.
- Postgate J. 1994. The outer reaches of life. Cambridge University Press