

YEAR – III	ENVIRONMENTAL MICROBIOLOGY (For the students who are admitted in the year 2019 – 2020 and onwards)	19EMB51A
SEMESTER - V		HRS/WK - 4
ELECTIVE		CREDITS - 3

Objective: To make the students understand the role of microbes in ecology.

Course Outcomes:

Upon successful completion of the course, the student:

CO 1: understands the different kind of microflora present in air and water environments

CO 2: will be able to know the different process to treat the waste water and drinking water

CO 3: knows about water pollution, and the process of composting and bioremediation

CO 4: knows different kinds of microbes present in extreme environments

CO 5: knows interactions among microorganisms and the study of non-cultivable microbes

SEMESTER: V	COURSE CODE: 19EMB51A					COURSE TITLE: ENVIRONMENTAL MICROBIOLOGY			HOURS: 4	CREDITS: 3
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	2	5	4	4	3	3	3	4	3.5	
CO2	2	4	4	4	4	3	4	3	3.5	
CO3	2	3	3	3	3	2	3	3	2.7	
CO4	3	5	4	4	4	3	5	4	4.0	
CO5	3	5	4	4	5	4	4	4	4.1	
Mean Overall Score									3.5	

Result: The score of this course is 3.5 (High)

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit – 1

(12 Hrs)

Microbiology of air – Droplet, droplet nuclei, aerosols - air sanitation - airborne diseases- Microflora of water - lakes, ponds, rivers, ocean, estuary, ground water - Waterborne diseases - Eutrophication

Unit - 2

(12 Hrs)

Waste water treatment - primary, secondary (anaerobic and aerobic - trickling, activated sludge, oxidation pond) - Sludge digestion - Disposal - Drinking water treatment -

chlorination - Microbiological standards of water

Unit - 3

(12 Hrs)

Water pollution – indicators of water pollution – BOD, COD; techniques for the study of water pollution; Composting; Bioremediation - types, importance, advantages and applications

Unit - 4

(12 Hrs)

Microorganisms in extreme environment - Applications of extremophiles; bioleaching; Microbial biofilm - Biochemistry of microbial biofilm, beneficial and harmful roles of biofilm.

Unit – 5

(12 Hrs)

Interaction among microbial populations (Neutralism, commensalisms, parasitism, antagonism); Microbial diversity - recent techniques to study non-cultivable microbes - Applications, advantages and limitations

Text Books

- Microbial Ecology - Fundamental and Applications. 1998. Atlas and Bartha. Benjamin/ Cummings Publishing Company, Inc., California
- Environmental Aspects of Microbiology. 1996. Joseph C. Daniel. Brightsun Publications, Chennai.

Reference Books

- Environmental Microbiology. 1992. Mitchell, R. John Wiley, New York.
- Environmental Microbiology. 1981. Grant W. D. and Long P.E. Blackie and Son Ltd., Glasgow
- Environmental Microbiology. 2016. Sharma, P.D. Rastogi Publications, Meerut, India.

YEAR – III	ALGAL TECHNOLOGY (For the students who are admitted in the year 2019 – 2020 and onwards)	19EMB51B
SEMESTER - V		HRS/WK - 4
ELECTIVE		CREDITS - 3

Objective: To make the students understand the role of algae and their cultivation methods

Course Outcomes:

Upon successful completion of the course, the student:

CO 1: knows the importance of algae and their occurrence

CO 2: understands the technique of microalgae cultivation

CO 3: studies mass cultivation of macro algae and different applications of seaweeds

CO 4: appreciates the economic importance of algae

CO 5: becomes familiar with the emerging technologies in algal biotechnology

SEMESTER: V	COURSE CODE: 19EMB51B					COURSE TITLE: ALGAL TECHNOLOGY			HOURS: 4	CREDITS: 3
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	3	4	3	3	3	4	4	4	3.50	
CO2	4	3	3	2	3	4	4	4	3.37	
CO3	3	3	3	3	2	4	4	4	3.25	
CO4	3	3	3	2	2	4	4	4	3.12	
CO5	3	4	3	2	3	4	4	4	3.37	
Mean Overall Score									3.29	

Result: The score of this course is 3.29 (High)

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit – 1

(12 Hrs)

Introduction to algal technology: Characteristics and classification of Algae - Chemical composition - protein, amino acids, lipids, waxes, glycerol, vitamins, pigments, chlorophyll, carotenoids and phycobiliproteins; Fresh water and marine algae – Macro and Micro algae – Occurrence – distribution.

Unit – 2**(12 Hrs)**

Microalgae - biofertilizers – nitrogen fixing forms – free living and symbiotic nitrogen fixers – *Azolla* – Blue-green algal bio-fertilizer - Method of preparation and application, importance and selection of carrier materials - Characteristics, significance and uses of the following algae - *Dunaliella*, *Chlorella*, *Scenedesmus*, *Porphyridium*, *Gracilaria*, *Gelidium*, *Gelidiella*, *Laminaria*, *Porphyra*, and *Ulva*.

Unit – 3**(12 Hrs)**

Macro algae - Mass cultivation, rope cultivation, Harvesting algae, Drying; Applications of seaweeds in biotechnology; liquid seaweed fertilizer; Algal immobilization and its applications.

Unit – 4**(12 Hrs)**

Economic importance of algae - Algae as a source of food and feed; Algae as SCP - *Spirulina* - mass cultivation and its applications; Algae as a source of pigments and fine chemicals; other bioproducts from algae; **Biofuel from algae - *Haematococcus* and *Botryococcus*.**

Unit – 5**(12 Hrs)**

Emerging Technologies in Algal Biotechnology - Laboratory cultivation of algae; Mass cultivation of algae; Culture media for algae; Methods of control of algae – Algicides - preparation and applications; Algal culture collection centers in India and abroad and their importance.

Text Book

- Algal cultural techniques. 2005 (1st Edition). Robert A. Anderson. Academic Press.

Reference Books

- Algae. 2011. Sharma, O.P. McGraw Hill Education (India) Private Limited.
- Algal biotechnology: Products and processes. 2016. Faizal, B. and Yusuf, C. Springer.
- Handbook of Microalgal culture: Biotechnology and applied phycology. 2004. Amos Richmond. Blackwell Publishing Ltd.
- Algae Energy. 2010. (1st Edition). Demirbas. Newness Publisher.
- Biotechnological Applications of Microalgae: Biodiesel and Value added products. 2013. (1st Edition). FaizulBux. 2013. CRC Press.

YEAR – III	BIOREMEDIATION (For the students who are admitted in the year 2019 - 2020 and onwards)	19SMB51A
SEMESTER - V		SELF STUDY COURSE
ELECTIVE		CREDITS – 2

Objective: To make the students aware of environmental pollutants and their biodegradation

Course Outcomes:

Upon successful completion of the course, the student:

CO 1: Understands Bioremediation and its types

CO 2: Lists the microbes involved in Bioremediation

CO 3: Knows the mechanisms of Bioremediation

CO 4: Understands the Bioremediation practices to treat soil and water pollution

CO 5: Is aware of the anaerobic treatments for different wastes

SEMESTER: V	COURSE CODE: 19SMB51A					COURSE TITLE: BIOREMEDIATION			HOURS: -	CREDITS: 2
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	2	3	3	4	4	2	5	4	3.37	
CO2	3	4	3	4	5	3	5	4	3.87	
CO3	2	3	3	5	5	3	5	5	3.87	
CO4	3	3	5	4	5	2	4	4	3.75	
CO5	2	3	4	3	4	2	4	4	3.25	
Mean Overall Score									3.62	

Result: The score of this course is 3.62 (High)

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit- 1

(6 hrs)

Pollution - Types of pollution; Pollutants - Types of pollutants; Acid mine drainage; Bioaccumulation and biomagnifications; Bioremediation - definitions, different strategies, Types of bioremediation, advantages and limitations.

Unit - 2

(6 hrs)

Microbes for bioremediation – Bacteria and fungi; Role of plasmids in bioremediation; Gene manipulation in creation of new strains; Phytoremediation.

Unit - 3**(6 hrs)**

Mechanism of bioremediation - Metabolic pathways for the degradation of xenobiotics; Bioprocess design – Optimization; Problems associated with biotreatment studies; Quantification of biodegradation.

Unit - 4**(6 hrs)**

Bioremediation of soil and effluents; Bioreactors - Advantages and disadvantages; Biodegradation of oil spill in marine environment; Biosorption of heavy metals.

Unit- 5**(6 hrs)**

Anoxic bioremediation; Fermentation; Anaerobic bioremediation of Hydrocarbons, Phenols, Chlorinated phenolic compounds, Polycyclic Aromatic Hydrocarbon (PAH), Dyes and Radioactive wastes.

Text book:

- Microbial Bioremediation. 2011. P. Rajendran and P. Gunasekaran. MJP Publishers, Chennai, India.

Reference books:

- Bioremediation; Principles and Applications (Biotechnology Research). 2005. R.L. Crawford, D.L. Crawford. Cambridge University Press
- Microbial Biodegradation and Bioremediation. 2014. Surajith Das. Elsevier
- Advances in Biodegradation and Bioremediation of industrial wastes. 2015. Ram Chandra. CRC Press
- Bioremediation of Pollutants. 2020. V.C. Pandey and V. Singh. Elsevier.
- Biotechnology. 2020. U. Satyanarayana and U. Chakrapani. Books and Allied Ltd, Kolkata, India

YEAR – III	ENTREPRENEURIAL MICROBIOLOGY (For the students who are admitted in the year 2019 – 2020 and onwards)	19SMB51D
SEMESTER - V		SELF STUDY COURSE
ELECTIVE		CREDITS – 2

Objective: To motivate the students to exploit the microbial techniques and resources to emerge out as an entrepreneur.

Course Outcomes:

Upon successful completion of the course, the student:

CO 1: will understand the basic concepts of entrepreneurship in microbiology.

CO 2: will describe different microbial products and their production methods.

CO 3: will get knowledge about mushroom cultivation and its uses.

CO 4: will appreciate the microbial pigments and their uses.

CO 5: will have knowledge on biofertilizers and brewing.

SEMESTER: V	COURSE CODE: 19SMB51D					COURSE TITLE: ENTREPRENEURIAL MICROBIOLOGY			HOURS: -	CREDITS: 2
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	2	5	4	4	3	3	3	3	3.3	
CO2	2	3	3	4	3	3	3	3	3.0	
CO3	2	4	4	4	3	3	3	3	3.2	
CO4	3	4	3	3	3	3	3	3	3.1	
CO5	3	4	4	5	4	3	3	4	3.7	
Mean Overall Score									3.2	

Result: The score of this course is 3.2 (High)

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit – 1

(6 hrs)

Introduction: Entrepreneur development – activity – Institutions involved – Government contributions to entrepreneurs – risk assessment– Qualities of an Entrepreneur – Factors influencing Entrepreneurship.

Unit - 2

(6 hrs)

Microbial products: Microbial cells as fermentation products- Baker’s yeast, food and feed

yeasts, Bacterial insecticides, Legume inoculants, Algae; Enzymes as fermentation products- Bacterial and Fungal Amylases, Proteolytic Enzymes, Pectinases, Invertases and other enzymes.

Unit - 3

(6 hrs)

Mushroom cultivation: Mushroom cultivation – edible and poisonous mushrooms – cultivation of *Agaricus campestris*, *Agaricus bisporus*, and *Volvariella volvaciae*, Preparation of compost, filling tray beds, spawning, maintaining optimal temperature, casing, watering, harvesting, storage. Mushroom recipes (Western and Indian recipes, pickles, jams etc.)

Unit - 4

(6 hrs)

Microbial pigments: Prodigiosin – violacein and deoxyviolacein – fungal Monascin – bacterial and algal carotenoids – astaxanthin – occurrence, isolation, chemical and biological properties – Catalysis – its applications and importance.

Unit - 5

(6 hrs)

Biofertilizers and Brewing: Biofertilizers - Historical background, **Chemical fertilizers versus biofertilizers, organic farming**. *Rhizobium* sp, *Azospirillum* sp, *Azotobacter* sp, as Biofertilizers. Brewing - media components, preparation of medium, microorganisms involved, maturation, carbonation, packaging, keeping quality, contamination, by-products.

Text books:

- Entrepreneurship: A south Asian Perspective. 2012 (1st Edition). Kuratko and Roa, Cengage Learning.
- Experiments in Microbiology, plant pathology Tissue culture and mushroom production technology. 2017 (6th Edition) K.R Aneja. New Age International Publication.

Reference books:

- Food microbiology. 2013 (5th Edition). William C. Frazier and Dennis C. Westhoff.
- Pigment Microbiology. 1992. Margalith P.Z. Chapman and Hall.
- Industrial Microbiology. 1986 (1st Edition) L.E. Casida. New Age Publication.

YEAR – III	SOIL AND AGRICULTURAL MICROBIOLOGY (For the students who are admitted in the year 2019 – 2020 and onwards)	19MB613
SEMESTER - VI		HRS/WK - 5
CORE - 13		CREDITS - 4

Objective: To make the students understand the importance of microbes in soil fertility and plant diseases.

Course Outcomes:

Upon successful completion of the course, the student:

CO 1: Understands different soil microflora and their roles in improving soil fertility

CO 2: Knows the plant-microbe interactions and their outcomes

CO 3: Studies different cyclical movement nutrients and different kinds of biofertilizers and biopesticides

CO 4: Understands different plant diseases due to bacterial and fungal phytopathogens

CO 5: Studies different plant diseases due to viruses and nematodes

SEMESTER: VI	COURSE CODE: 19MB613					COURSE TITLE: SOIL AND AGRICULTURAL MICROBIOLOGY			HOURS: 5	CREDITS: 4
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	2	5	4	4	3	3	3	4	3.5	
CO2	2	4	4	4	4	3	3	4	4.3	
CO3	2	3	3	4	3	2	3	3	2.8	
CO4	3	5	4	4	4	3	5	4	4.0	
CO5	3	3	3	5	5	4	4	4	3.8	
Mean Overall Score									3.6	

Result: The score of this course is 3.6 (High)

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit - 1

(15 Hrs)

Soil – physical and chemical properties; soil microorganisms - bacteria, algae, fungi, actinomycetes, protozoans, nematodes and viruses – Influence of soil and environmental factors on soil microflora - **Role of microbes in soil fertility** - Winogradsky column.

Unit - 2 (15 Hrs)
Microbial interactions with plants - Mycorrhizae, Rhizosphere, Phyllosphere, Spermosphere-
Plant growth promoting bacteria – Mechanisms of plant growth promotion - Organic matter
decomposition - humus formation - Biodegradation of pesticides in the soil

Unit - 3 (15 Hrs)
Biogeochemical cycles - carbon, phosphorus, sulphur, Iron and nitrogen cycles; Nitrogen
fixation – symbiotic and free living; Biofertilizers - Types (bacterial and algal), Examples and
advantages; Biopesticides - types (bacterial, fungal and viral), Examples and advantages;
Mass multiplication of microbial Bioinoculants

Unit – 4 (15 Hrs)
Plant pathogenic microorganisms - Disease symptoms, mode of entry, control measures -
Diseases caused by bacteria – bacterial Wilt of potato- Citrus canker, leaf blight of paddy as
examples - Diseases caused by fungi - False smut of paddy, Leaf smut of rice, wheat rust,
Red rot of sugarcane and Tikka disease of groundnut as examples

Unit - 5 (15 Hrs)
Diseases caused by viruses - Tungrovirus, Virus diseases of papaya and sugarcane – Bunchy
disease of banana – Leaf curl of tomato as example - Diseases caused by *Mycoplasma* -
Little leaf of brinjal as example – Diseases due to Phytoplasma - Sugarcane grassy shoot
disease as example - Diseases due to nematodes – Root knot of vegetables as example –
Seed borne diseases.

Text Books

- Diseases of crop plants in India. 1999 (4th Edition). G. Rangaswami, A. Mahadevan. Prentice – Hall of India Private Ltd., New Delhi.
- Agricultural Microbiology. 1998 (2nd Edition). G. Rangaswami, D. J. Bagyaraj. Prentice -Hall of India Private Ltd., New Delhi, India

Reference Books

- Microbiology - Fundamentals and Applications. 1998. Atlas and Bartha. Benjamin/Cummings Publishing Company, Inc., California.
- Introduction to Soil Microbiology. Alexander. M. 1961. John Wiley Sons, Inc. New York & London.
- Fundamental Agricultural Microbiology. 2017. Aneja, K.R. International private limited, Chennai, India
- Fundamental of Plant Pathology. 2013. Ravichandra, N.G. PHI publishers, New Delhi, India
- A Textbook of Plant Pathology. 2020. Sambamurty, A.V.V.S. Dreamtech Press, New Delhi, India

YEAR – III	BIOTECHNOLOGY (For the students who are admitted in the year 2019 – 2020 and onwards)	19MB616
SEMESTER - VI		HRS/WK - 5
CORE - 16		CREDITS - 4

Objective: To make the students understand the basic principles and techniques involved in gene technology

Course Outcomes:

Upon successful completion of the course, the student:

CO1: Understands the basics of recombinant DNA technology and cloning vectors.

CO2: Gains knowledge about the DNA and its amplification.

CO3: Acquires knowledge about enzymes and biofuels.

CO4: Understands the usage of plants and exploitation of them through genetic modification

CO5: Understands the usage of animals and exploitation of them through genetic modification, patenting and intellectual property rights.

SEMESTER: VI	COURSE CODE: 19MB616					COURSE TITLE: BIOTECHNOLOGY			HOURS: 5	CREDITS: 4
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	3	4	4	4	3.5	3	3.5	4	3.62	
CO2	3	4	4	4	4	3	4	3.5	3.68	
CO3	4	3	3.5	3	3	4	3.5	3	3.37	
CO4	3.5	4	4	4	4	3	4	4	3.81	
CO5	3	4	4	4	4	4	4	4	3.87	
Mean Overall Score									3.67	

Result: The score of this course is 3.67 (High)

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit - 1

(15 Hrs)

Definition and history – Recombinant DNA technology – Restriction endonucleases- Cloning vectors – pBR322, Cosmids - M13 phage vector and its applications – DNA ligation.

Unit - 2

(15 Hrs)

Chemical synthesis of DNA - DNA sequencing – Hybridisation techniques - Southern and Northern blotting techniques – Colony hybridization - PCR – Genomic library.

Unit - 3 (15 Hrs)
Enzyme technology – Enzyme immobilisation, products, Applications - **Biofuel** –Hydrogen gas as fuel from Microorganisms – **Biodiesel**.

Unit - 4 (15 Hrs)
Genetic engineering of plants – Electroporation – Gene gun –Particle bombardment- Ti plasmid vectors –Cauliflower mosaic virus as cloning vector - Applications- Transgenic plants –Insect resistant, Virus resistant plants, genetically modified foods.

Unit - 5 (15 Hrs)
Transgenic animals –Retroviral vector method , DNA microinjection method –Applications of r DNA technology – Recombinant products –insulin, tPA, Interferons – Gene therapy – Patents – IPR.

Text Books

- Elements of Biotechnology. 1996. Gupta, P.K. Rastogi and Company, Meerut.
- Basic Biotechnology. 2001 (2nd edition). Ratledge C. and B. Kristiansen. Cambridge University press, United Kingdom.

Reference Books

- Principles of Gene Manipulation. 1994 (5th Edition).Old, R.W. and S.B.Primrose. Blackwell Science, Oxford.
- Molecular Biotechnology - Principles and Applications of Recombinant DNA technology. 2010 (4th Edition). Glick, B. R., Pasternack J.J. and Patten C.L.ASM Press.
- Genetics- A Molecular Approach. 2004. Brown, T.A. Chapman Hall, London.
- Biotechnology Expanding Horizons. 2021. Singh, B.D. Kalyani Publishers, Ludhiana.

III B.Sc. Microbiology	APPLIED MICROBIOLOGY PRACTICAL (For the students who are admitted in the year 2019 – 2020 and onwards)	19MBP603
SEMESTER – V & VI		HRS/WK - 3
CORE PRACTICAL - 3		CREDITS – 3

LIST OF EXPERIMENTS

1. Open plate method
2. Enumeration of bacteria from water sample
3. Coliform count in water (MPN Technique)
4. Presence/Absence test for coliforms in water
5. Microscopic Examination of curd
6. Isolation of *Lactobacillus* and *Staphylococcus* from curd
7. Microscopic examination of fungi by Lactophenol cotton blue method – *Mucor* and *Rhizopus*
8. Microscopic examination of microorganisms in spoiled food
9. Isolation of bacteria from spoiled food
10. Detection of bacteria in milk by SPC
11. Methylene blue reduction test
12. Phosphatase test for Milk
13. Turbidity test for sterilized Milk
14. Cross section of root nodule

LIST OF SPOTTERS

1. Butter
2. Cheese
3. Canned food
4. Spoiled vegetable
5. Spoiled bread
6. *Rhizopus* - Lactophenol cotton blue mount
7. *Mucor*- Lactophenol cotton blue mount
8. BOD bottle
9. Membrane filter
10. Trickling filter
11. Lactophenol cotton blue stain
12. Methylene blue for MBRT
13. Yeast
14. Bread
15. Vinegar
16. Mushroom
17. *E. coli* on EMB agar
18. Lactose fermenting colonies on MacConkey agar
19. YEMA medium
20. Root nodule
21. Cross section of root nodule

22. MPN Preliminary test - Lauryl tryptose broth with durhams tube
23. MPN Confirmed test - Brilliant green lactose bile broth with durhams tube
24. Curd
25. Milk
26. Milk sample with Methylene blue in screw cap tube
27. Teasing needle
28. *Lactobacillus* on Ovgall Agar
29. Staph. aureus on Baird parker agar

III B.Sc. ZOOLOGY	BIOFERTILIZER TECHNOLOGY For the students admitted from the year 2018-19 onwards	20EZ513A
SEMESTER - V		HRS/WK - 4
ELECTIVE		CREDIT - 2

Objective: To enable the students learn the importance of biofertilizers and their production

- To enlighten the students with the knowledge of microbial inoculants
- To highlight the role of microorganisms in soil fertility and plant growth promotion
- To understand the process of isolation, production, formulation, method of application and quality control of bio-fertilizers

Course Outcomes:

Upon successful completion of the course, the student:

CO 1: will be able to appreciate the role of soil microorganisms

CO 2: will be able to describe various nitrogen fixing organisms

CO 3: will be able to explain different nutrient solubilizing bacteria

CO 4: will be able to gain knowledge on production of biofertilizers

CO 5: will be able to elaborate on the formulation of biofertilizers

SEMESTER: V	COURSE CODE: 20EZ513A					TITLE OF THE PAPER: BIOFERTILIZER TECHNOLOGY			HOURS: 4	CREDITS: 2
COURSE OUTCOMES	PROGRAMME OUTCOMES (PO)					PROGRAMME SPECIFIC OUTCOMES (PSO)			MEAN SCORE OF COs	
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3		
CO1	3	2	5	5	4	4	4	5	4.0	
CO2	2	2	5	5	3	3	5	5	3.7	
CO3	2	2	4	5	4	3	5	5	3.7	
CO4	4	2	4	4	4	3	4	4	3.6	
CO5	4	2	4	4	4	3	5	5	3.8	
Mean Overall Score									3.7	

Association	1%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Scale	1	2	3	4	5
Interval	0<=rating<=1	1.1<=rating<=2	2.1<=rating<=3	3.1<=rating<=4	4.1<=rating<=5
Rating	Very Poor	Poor	Moderate	High	Very High

This Course is having **HIGH** association with Programme Outcomes and Programme Specific Outcomes.

Unit – 1

(12 Hrs)

SOIL MICROORGANISMS AND PLANTS: Important groups of soil microorganisms - Bacteria, Fungi, Algae, Protozoa, and Viruses - Microbial interactions in soil- positive and

negative interactions - Rhizosphere – Phyllosphere -Spermosphere - R:S ratio; Biofertilizers – definition, types, importance of biofertilizers in agriculture; Plant Growth Promoting Rhizobacteria (PGPR) and their products - Cytokinin, Gibberellic acid, IAA, HCN and Siderophore.

Unit – 2

(12 Hrs)

NITROGEN FIXERS: Biological nitrogen fixation (BNF) - mechanism of BNF - Symbiotic nitrogen fixation - legume symbiosis- Rhizobium- characters and classification, nodulation- Free living nitrogen fixation - BGA, Azolla, Azospirillum, Azotobacter, Glucanoacetobacter and Frankia.

Unit – 3

(12 Hrs)

NUTRIENT SOLUBILIZERS AND MOBILIZERS: Solubilization of insoluble P, K, Zn and Si; Important solubilizing bacteria and fungi - Mycorrhizal bioinoculants – classification - Ectomycorrhizae – Endomycorrhizae -VAM- Taxonomy of mycorrhizae – role of mycorrhizae.

Unit – 4

(12 Hrs)

PRODUCTION TECHNOLOGY: Isolation and mass multiplication of Nitrogen fixers (*Rhizobium*), P, K, Zn and Si solubilizing organisms (*Pseudomonas*), BGA, *Azollae*and Mycorrhizae - Carrier materials – selection, sterilization and preparation of carrier materials – fermenters.

Unit – 5

(12 Hrs)

FORMULATION OF BIOFERTILIZERS: Carrier based, gel based and liquid based biofertilizers - Quality control of different formulations – Problems and constraints in production- Methods of application and recommendations

Text Books

- Soil Microbiology.199 (4th Edition). Subba Rao N.S. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India
- Agricultural Microbiology. 2002(2nd Edition).Bagyaraj D.J. and G. Rangasamy. Prentice Hall, New Delhi, India

Reference Books

- Microbes as Bio-fertilizers and their production Technology. 2015. Borkar S.G. Wood Head Publishers, New Delhi.
- Biofertilizers: Commercial production Technology and quality control. 2017. Hyma P. Random publishers, New Delhi
- Biofertilizer Manual. 2006. FNCA (Forum for Nuclear Cooperation in Asia) Biofertilizer Project Group. Published by Japan Atomic Industrial Forum.