

**M.Sc. Environmental Microbiology**  
**Department of Environmental Microbiology**  
**School for Environmental Sciences**  
**BBA University, Lucknow**  
**Revised by BPGS held on 19/05/2015**

### Semester I

Paper Code	Title of Paper	Credits	Type
EM 101	Concepts of Microbiology and Biosafety	06	Core
EM 102	Microbial Biochemistry	06	Core
EM 103	Statistics, Computers and Bioinformatics*	06	Optional*
EM 104	Practical	06	Core
EM 105	Microbial World – Study and Applications#	06	Optional for CBCS#

\* Students of M.Sc. Environmental Microbiology can either opt EM 103 or paper of equal credits in other course

# Course offered under CBCS for students of other courses

### Semester II

Paper Code	Title of Paper	Credits	Type
EM 201	Analytical Tools and Techniques	06	Core
EM 202	Microbial Physiology and Adaptations	06	Core
EM 203	Molecular Biology and Microbial Genetics*	06	Optional & for CBCS*
EM 204	Practical	06	Core

\* For Choice Based Credit System

### Semester III

Paper Code	Title of Paper	Credits	Type
EM 301	Environmental Pollution and Bioremediation	06	Core
EM 302	Microbiology of Agro Environment	06	Core
EM 303	Food and Industrial Microbiology*	06	Optional*
EM 304	Practical	06	Core
EM 305	Applied Environmental Biotechnology#	06	Optional for CBCS#

\* Students of M.Sc. Environmental Microbiology can either opt EM 103 or paper of equal credits in other course

# Course offered under CBCS for students of other courses

### Semester IV

**EM 401 Dissertation Work/ Industrial Training (24 Credits)**

**Qualifying courses for personality development:**

<b>Paper Code</b>	<b>Title of Paper</b>	<b>Semester</b>	<b>Credits</b>
MPDC**-105	Remedial Language Course	I	01
MPDC**-205	Moral Studies	II	01
MPDC**-305	Community Service	III	01
MPDC**- 405	Ambedkar Studies <sup>φ</sup>	IV	01

# **M.Sc. Environmental Microbiology**

## **I Semester**

### **EM 101 Concepts of Microbiology and Biosafety (06 Credits)**

**Core**

**Unit I** History of Microbiology, General structure and classification of bacteria, fungi and viruses, Isolation/ Identification/ Enumeration and preservation of microorganisms, control of microorganisms (physical and chemical).

**Unit II** Ultrastructure of microbial cell (Gram positive and Gram negative bacterial membrane, spore, pili, flagella), Locomotion in bacteria, Prokaryotic cellular reserve materials, Microbial growth and nutrition.

**Unit III** Concept of Environment and Ecology, Ecosystems, Biogeochemical cycles, Study of population growth and Community dynamics in microbes, Microbial diversity, effects of environmental factors on microbes, microbial succession, aerobiology of microbes.

**Unit IV** Biosafety, regulations for microbial products, regulations for laboratories, national and international biosafety protocols, biological weapons, assessment of recombinant products, regulatory authorities.

### **EM 102 Microbial Biochemistry (06 Credits)**

**Core**

**Unit I** Bioenergetics and strategy of metabolism: flow of energy through biosphere, strategy of energy production in the cell, oxidation reduction reactions, coupled reactions and group transfer, ATP production, structural features of biomembranes, transport, free energy and spontaneity of reaction,  $G$ ,  $G^0$ ,  $G'$  and equilibrium, Physico-chemical properties of water, Handerson-Hasselbalch equation, Dielectric constant, pH and pKa values, buffers.

**Unit II** Classification and structure of carbohydrates and their metabolism, Classification of lipids, structure, function and their metabolism.

**Unit III** Structure, function and classification of amino acids and proteins: peptide bond, primary, secondary (Ramachandran plot), tertiary and quaternary structure of proteins. Structure and function of nucleic acids, their biosynthesis and breakdown.

**Unit IV** Enzymes as biocatalysts, enzyme classification, specificity, active site, activity unit, isozymes. Michaelis-Menten equation for simple enzymes, determination of kinetic parameters, multistep reactions and rate limiting steps, enzyme inhibition, allosterism, kinetic analysis of allosteric enzymes, principles of allosteric regulation. Vitamins and their role as coenzymes.

## **EM 103 Statistics, Computers and Bioinformatics (06 Credits) (Optional Paper)**

**Unit I** Introduction to statistics: mean, median, mode, standard deviation. Sampling methods – simple, random, stratified, systematic and cluster sampling procedures. Probability distribution, Chi-square test, ‘t’ and ‘f’ test, analysis of variance.

**Unit II** Introduction to computers – classification of computers, computer generation – low, medium and high level languages, software and hardware, operating systems, computer memory and its types, binary system and its relationship to Boolean Operations.

**Unit III** Microsoft Office, Multimedia network concepts, C programming, LAN, WAN, HTML and XML concepts

**Unit IV** Overview of bioinformatics – data basis types, genomics and the genome project, computer tools for sequence analysis: finding and retrieving sequences, similarity searching. Pair wise and multiple alignment, structure function relationships, phylogenetic tree construction.

## **EM 104 Practical (06 Credits)**

### **Core**

1. To study the principle, working and applications of light microscope, centrifuge, pH meter, hot air oven, autoclave, laminar air flow chamber.
2. To perform simple staining of bacteria and fungi.
3. To perform negative staining of bacteria.
4. To perform Gram staining of bacteria.
5. To perform endospore staining.
6. To check motility by hanging drop method, broth and surface.
7. To prepare basic liquid media (broth) for routine cultivation of bacteria.
8. To prepare basic solid agar media slants for routine cultivation of bacteria.
9. Types of media – differential, selective, synthetic.
10. Isolation and enumeration of microbes from soil sample by serial dilution agar plating method or by viable plate count method.
11. Direct microscopic count.
12. To obtain axenic culture of microbes by streak, spread, pour plate methods.
13. Techniques for preservation of microbial cultures.
14. To preserve microbes by freeze drying (lyophilization).
15. Carbohydrate estimation by Anthrone method.
16. Protein estimation by Lowry's, Bradford and
17. To plot bacterial growth curve by spectrophotometer.

## **EM 105 Microbial World - Study & Applications (06 Credit) Optional Paper for CBCS**

**Unit 1** Microbial world- Monera (Eubacteria & archaeobacteria), Protista. Fungi and Viruses, Characteristic features. Application of Microbes for industrial uses, products for human consumption, products for agriculture, roles in environment.

**Unit 2** Cultivation of microbes in laboratory (bacteria, fungi and viruses), techniques to study microbial cells, microscopy – light, electron, phase contrast

**Unit 3** Control of microorganisms by physical and chemical methods, preservation of microbes, culture collection centres, biological information and database.

**Unit 4** Hands on training on principles and working of common equipment of microbiology laboratory, isolation techniques (of microbes), cultivation in laboratory, staining techniques, growth studies.

### TEXTBOOKS

- Environmental Microbiology and Biotechnology by Singh and Dwivedi. New Age Int. Sci. Publication.
- Environmental Microbiology by Riana.
- Microbiology by Prescott, Harley and Klein. TMH Publication.
- Brock Biology of Microorganisms. Prentice Hall Publication.
- General Microbiology by Stanier. MacMillan Education Ltd.
- Environmental Microbiology: Principles and Applications. Patrick K. Jjemba.
- Encyclopedia of Environmental Microbiology, 6 Vol. Set. Willey Publication.
- Microbial Ecology by Alexander. Willey Publication.
- Microbial Diversity: Form and Function of Prokaryotes. Wiley Blackwell Publication.
- Principles of Biochemistry by Lehninger.
- Statistics for Biologists by Campbell R C. Cambridge University Press.
- Statistics in Biology by Bliss C I K. MGH Publication.
- Bioinformatics by Higgins and Taylor.
- Introduction to Bioinformatics by Arther M Lesk. Oxford Publication.
- Biodiversity and Environmental Biotechnology by Dwivedi and M C Kalita. Scientific Publication.
- Experiments in Microbiology, Plant Pathology and Biotechnology by K R Aneja. New Age Publication.
- Laboratory Exercise in Microbiology by Prescott and Harley. MGH Publication.
- Media Used for Environmental Microbiology by Ronald and Atlas. Taylor and Francis Publication.
- Bioinformatics, Higgins and Taylor, OUP.

### REFERENCE BOOKS

1. Virology by John Carter. Wiley Publication.
2. Livero Microbial Ecology of Aerial Plant Surface. CABI International.
3. Fungal Biology, Jim Deacon. Wiley Publication.
4. The Fungi. M. Charlie. Academic Press.
5. Microbial Diversity: Form and Function in Prokaryotes. Wiley-Blackwell.
6. Alexander Introduction to Soil Microbiology. Wiley Publication.

## II Semester

### **EM 201 Analytical Tools and Techniques (06 Credits)**

**Core**

**Unit I** Micrometry, Microscopy techniques: Simple, Phase contrast, Fluorescence, Electron and Confocal Microscopes.

Principle and applications of electrophoresis, PAGE, SDS-PAGE, 2D, PFGE.

**Unit II** Principles and applications of centrifugation and ultracentrifugation. Chromatography: paper, Thin-layer and Column Chromatography, gas chromatography (GC) and HPLC, basic concepts of IR and NMR.

**Unit III** Electromagnetic spectrum, Beer Lambert's law, Extinction coefficient, Principles and application of UV-Visible spectrophotometer, UV-VIS Spectrofluorimeter, ESR, Atomic absorption spectrophotometer, Radio-tracer technique, autoradiography, basic concepts of MALDI TOF and ESMS.

**Unit IV** Principle and working PCR and its variants, DNA sequencing, Working and applications of RFLP, RAPD, ARDRA, DGGE, TGGE.

### **EM 202 Microbial Physiology and Adaptations (06 Credits)**

**Core**

**Unit I** Bacterial photosynthesis: oxygenic and anoxygenic photosynthesis, photosystems and electron transport system, photophosphorylation, photorespiration

**Unit II** Extremophiles – thermophiles, psychrophiles, osmophiles (halophiles, saccharophiles), acidophiles, alkalophiles, barophiles, xerophiles. Physiology and metabolism of archaeobacteria.

**Unit III** Concept of stress and stress tolerance, signaling molecules and signal transducing machinery in microbial system. Transmitter and receiver proteins. Concept of free radicals.

**Unit IV** Nature and effects of temperature and oxidative stresses. Effect of UV radiations on microorganisms, UV induced damage to microorganisms, photo repair, dark repair and SOS inducible repair mechanisms against UV induced damage.

### **EM 203 Molecular Biology and Microbial Genetics (06 Credits)**

**Optional**

**Unit I** Genes, genome organization, C-value paradox, cot analysis, repetitive DNA, circular and superhelical DNA, central dogma, concept and properties of genetic code, DNA replication.

**Unit II** Mutation: types of mutation, molecular basis of mutagenesis, genetic analysis of mutants, mutant reversion, transposons. Gene regulation: positive and negative control, operon concept- induction, repression, attenuation, regulon, global regulatory network.

**Unit III** Genetic recombination: restriction and modification, types of recombination-transformation, conjugation, transduction.

**Unit IV** Plasmids, construction of genomic libraries. Application of recombinant DNA technique, amplification of recombinant DNA, DNA finger printing, gene mapping. Thermostable enzymes: Taq and Pfu.

### **EM 204 Practical (06 Credits)**

**Core**

1. To study the microscopic techniques (fluorescence, phase contrast)
2. Micrometry for analysis of microbial cells.
3. To learn the chromatographic techniques (TLC/ HPLC/ GC)
4. To learn techniques of spectrophotometry (UV-VIS/ AAS)
5. To learn the molecular techniques for identification of microbes.
6. To demonstrate the oxygenic photosynthesis by algae/ blue green algae.
7. To determine the membrane transport of nutrients in the given organism.
8. Calculation of mutation frequency in microbes after mutagenesis.
9. Extraction and separation of DNA by agarose gel electrophoresis.
10. Estimation of lipid per oxidation in microorganism under oxidative stress.
11. Protein gel electrophoresis for separation of proteins.
12. Selective enrichment techniques for isolation of auxotrophs.
13. Isolation of extremophiles by selective techniques.
14. Demonstration of stress enzymes/ proteins from extremophiles.

### TEXTBOOKS

1. Bacterial Stress Responses, Blackwell Publishing.
2. Biotechnology 2, Biotechnology 4 by S Mahesh and A B Vedamurthy, New Age Publication.
3. Bensons Microbiology Application by Alfred E Brown. MGH Publication.
4. Microbial Physiology by Moat and Foster. Wiley-Liss Publication.
5. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempey.
6. Microbial Ecology by Atlas and Bartha
7. Microbial Genetics, Stanley Narosa Publication.
8. Genetics by T A Brown, Bios Scientific Publication.
9. Gene IX by Benjamin Lewin Pearson, Prentice Hall Publication.
10. Molecular Cell Biology, W H Freeman

### REFERENCE BOOKS

1. Medical Microbiology by R Pajarathinam. New Age Publication. Cell Biology by Lodish. W H Freeman Publication.
2. Cell and Molecular Biology by Bruce Albert.
3. Extremophiles, Springer Verlag

### **III Semester**

#### **EM 301 Environmental Pollution and Bioremediation (06 Credits)**

**Core**

**Unit I:** Limnology, factors governing microflora and their distribution in natural water, Microbiology of oceans. Municipal treatment of drinking water.

Water pollution and its sources. Role of organic pollutants in water, concepts of C-BOD, N-BOD and COD, Oxygen-sag curve. Treatment of waste water by aerobic and anaerobic process. Water borne diseases and pollution, Biomonitors of environmental contamination.

**Unit II:** Microbial tolerance mechanisms and degradation of heavy metals and xenobiotic compounds- pesticides, hydrocarbons, plastics and paints.

**Unit-III:** Particulate matters, PAH, Fog and smog, Determination of LD50, Ames test to determine the genotoxicity of toxicants.

**Unit IV:** Occurrence, Mode of spread of communicable diseases, Principles of virulence and pathogenicity, Immune response specific and non-specific immunity, antigens and antibody, Cell mediated and humoral immunity, hybridoma technology, Immunosuppression.

#### **EM 302 Microbiology of Agro Environment (06 Credits)**

**Core**

**Unit I** Soil profile and humus formation, Microbial interactions, Rhizosphere, PGPRs, Concepts of antibiosis and biological control, secondary metabolites, microbial toxins, Biopesticides.

**Unit II** Nitrogen-fixing microorganisms, process of nitrogen fixation in the free living and symbiotic microorganisms, regulation of nitrogenase, Nif gene, phosphate solubilization Mycorrhizae, Biofertilizers – application.

**Unit III** Single cell protein, mycoprotein, rDNA technology and its application in Agriculture, Environment and healthcare, GMO's and GEM's- Role of Agrobacterium, Ti Plasmid, transgenic crops, issues related to transgenic organisms, Degradation of lignocellulosic waste, Biocomposting, Biogas. Leaching of metal from ores.

**Unit IV** Soil pollution, microbes as indicators of soil pollution, Toxins and toxoids, source and chemistry of microbial toxins, aflatoxins, fusariotoxins, contamination of food grains and food products, microbial remediation of soil contaminants.



## **EM 303 Food and Industrial Microbiology (06 Credits)**

**Optional**

**Unit I** Bioprocess technology: Bioreactors, types of fermenters – basic, continuous, anaerobic solid state and submerged fermentations, scaling up, strategies for selection and improvement of industrially important strains, downstream processing.

**Unit II** Production of citric acid, acetic acid, alcohol – beverages and industrial, enzymes - curd, bakery products and vinegar, Biopolymers – xanthan gum and PHA's (bioplastics),

**Unit III** Production of antibiotics – penicillin, streptomycin, production of vitamins (A, B), recombinant proteins, Transformation of steroids, immobilization of microbial cells/ enzymes.

**Unit IV** Fermented foods – cheese and dairy products, fermented vegetables and meats, fermented oriental foods. Food spoiling microorganisms, food borne infections and intoxications, preventive measures, food control agencies and regulations. Microbial deterioration of leather, jute, cotton, paper, paint.

## **EM 305 Applied Environmental Biotechnology (06 Credits) – For CBCS**

**Unit I** Utilization of agroindustrial waste for microbial biomass and protein. Biofuels-using Algae, hydrogen as green fuel, ethanol as biofuel, microbial biomass from agricultural wastes and lignocellulose. Microbiology of biogas generation

**Unit II** Soil fertility and management of agricultural soil: soil microflora and organic matter decomposition, rhizosphere, Soil-plant-microbe interactions, Biofertilizers, Biopesticides, Microbial deterioration and methods of preservation.

**Unit III** Role of microbes in bioremediation, r-DNA technology and its application in healthcare, environment, agriculture. Microbial enzymes and their application, Fermented food, feed, tea and coffee, Petroleum and mining microbiology, Biotransformation of steroids

**Unit IV** Biodegradation of xenobiotic compounds, treatment and safety of water supply, low cost technologies for treatment of drinking water, Biosafety regulations

## **EM 304 Practicals (06 Credit)**

1. Estimation of microbial flora on seeds.
2. To determine the food quality and its deterioration by measuring the microbial population.
3. To determine the MIC of given antibiotic (streptomycin) by observing its effect on bacterial culture.
4. To prepare the selective and differential (EMB) medium.

5. Isolation of *E. coli* from sewage water samples with the help of EMB agar medium.
6. To determine the Total Dissolved Solids (TDS), Total Suspended Solids (TSS) in given water sample.
7. Quantitative estimation of nitrate in given water sample.
8. To determine the amount of Dissolved Oxygen (DO) present in given water sample.
9. To determine the Biological Oxygen Demand (BOD) of given waste water sample.
10. To determine the blood group and Rh factor by serum agglutination test.
11. Isolation of symbiotic *Rhizobium* from plant root nodules.
12. Isolation of symbiotic *Anabaena/ Nostoc* from gymnospermic plant roots.
13. Isolation of aquatic fungi by baiting technique.
14. Estimation of ethanol production by microbial fermentation.
15. Measurement of toxicity of metals and pesticide to microorganisms for determination of LD<sub>50</sub>.
16. Cultivation of mushroom on agro biomass.
17. Immobilization of microbial cells for biotransformation of industrial products.
18. To check the phenomenon of antagonism by dual culture technique.
19. To isolate phosphate solubilizing microorganisms.
20. To check the nitrogenase activity by AR assay.

### TEXTBOOKS

1. Waste Water Microbiology by Garbiel, Bitton. Wiley Publication.
2. Biopesticides: A Biotechnical Approach by S R Joshi. New Age Publication.
3. Microbial Ecology by Atlas and Bartha.
4. Soil Organic Matter and Biological Activity. Martinus Nigholf W Junk Publisher.
5. Introduction to Environmental Microbiology by Michel Wiley Liss Publication.
6. Advances in Microbial Ecology. K C Marcell, Plenum Press.
7. Textbook of Microbiology by Paniker. Orient Longman Publication.
8. Immunology by Nandini Shetty. New Age Publication.
9. Immunology by Kuby. W H Freeman Publication.
10. Immunology. Garland Publication.
11. Bioremediation by Baker. MGH Publication.
12. Toxicological Chemistry by Stanley E Manahan. Lewis Publication.
13. Textbook of Modern Toxicology by Ernest Hodgson. Wiley Interscience Publication.
14. Biotechnology for Waste Water and Waste Water Treatment, Prentice Hall of India
15. Modern Food Microbiology by James M Jay, Anaspen Publication.
16. Food Microbiology, Frazier, TMH Publication.
17. Food Microbiology by M R Adams, New Age Publication.
18. Food Fermentation and Microorganism, Wiley Publication.
19. Industrial Microbiology by L E Casida, New Age Publication.
20. Biogas Technology by B T Nijaguna, New Age Publication.

21. Microbial Biodegradation: Genomics and Molecular Biology, Caister Academic Press.
22. Bioremediation: Applied Microbial Solutions for Real-World Environmental Cleanup. R M Atlas and J Cphilp Eds.

#### REFERENCE BOOKS

1. Waste Water Engineering by Metcalf and Eddy. MGH Publication.
2. Plant Microbe Symbiosis: Fundamentals and Advances, Springer
3. Plant Microbes Symbiosis: Applied Facets, Springer
4. *In Situ* Bioremediation: When Does It Work? National Academics.
5. Drinking Water and Health. Vol 6. National Academics.
6. Indicator of Waterborne Pathogen. National Academics.
7. Classifying Drinking Water Contaminant for Regulatory Consideration. National Academics.
8. Bacterial Biofilms, Springer Publication.

### IV Semester

**EM 401 Dissertation Work (24 Credit)**

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