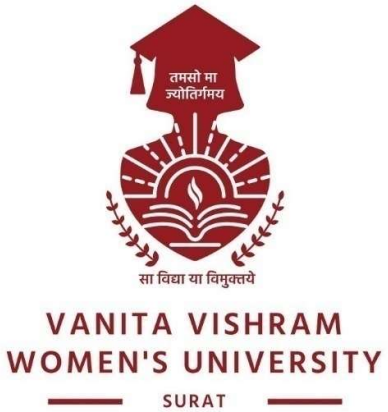
VANITA VISHRAM WOMEN'S UNIVERSITY
SCHOOL OF SCIENCES
DEPARTMENT OF MICROBIOLOGY



MASTER OF SCIENCE (M.Sc.) MICROBIOLOGY PROGRAMME
under Learning Outcomes-based Curriculum Framework (LOCF)
for Post Graduate (PG) Education

SEMESTERS 2
Core Courses (CC)

Syllabus applicable to the students seeking admission in the M.Sc.- Microbiology
under LOCF
w.e.f. the Academic Year 2023-2024

MASTER OF SCIENCE MICROBIOLOGY

SEMESTER 2
CORE COURSE PAPER 5
MB21260 ENVIRONMENTAL MICROBIOLOGY

Course Objectives:

The major objective of this paper is to impart knowledge about the structure, composition and functioning of microbial communities in a diverse environment. The use of microbial population in agriculture, mineral recovery, management of various types of pollutants and conversion processes of various types of wastes into value added products will be discussed.

Course learning outcomes : By the end of this course the students-

CO1.Will have an overview of the till date developments in the field of environmental microbiology with special emphasis on the role of microbes in mitigating environment pollution.

CO2.Will have become acquainted with various cultural, biochemical and molecular techniques used in understanding microbial diversity.

CO3. Will be knowledgeable about the diversity, adaptations and biotechnological applications of microbes of extreme environment.

CO4. Will be able to describe the role of soil microbes in nutrient transformation, plant-microbe interactions and biotechnology. Also knows about potability of water and its quality control.

THEORY COURSE
(4 Credits)

Unit-1	**Environmental microbiology& Microbial diversity in extreme environments:** Development of microbial ecology and emergence of field of environmental microbiology, significant applications of microbes in solving environmental pollution problems, Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles. Biotechnological applications of the same	**15 Lectures**
Uni-2	**Soil and water microbiology:** Importance of soil microorganisms, nutrient transformation processes, plant-microbe symbiosis, microbial antagonism, biofilms and their biotechnological applications, drinking water microbiology and quality control.	**15 Lectures**
Unit-3	**Liquid and solid waste management:** Treatment of sewage (primary, secondary and tertiary treatments), treatment of industrial effluents (distillery, textile, pulp and paper- biopulping, biobleaching), methods to detect various pollutants (metals, sediments, toxin and organic matters). Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, biofuels &biogas production, challenges in waste management. Lignocellulolytic microorganisms, animal feed production.	**15 Lectures**

Unit-4	**Bioremediation of environmental pollutants:** Petroleum hydrocarbons and pesticides, plastic degrading microorganisms as a tool for bioremediation, use of biosensors for their detection. Microbial enhanced oil recovery, bioleaching of copper, gold and uranium, electronic waste management.	**15 Lectures**

Reference Book

1. Microbial Ecology by R.M. Atlas, R. Bartha. 3rd edition. Benjamin Cummings Publishing Co, USA. 1993.
2. Environmental Microbiology by A.H. Varnam, M.G. Evans. Manson Publishing Ltd. 2000.
3. Manual of Environmental Microbiology edited by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson, A. L. Mills, L.D. Stetzenbach. 3rd edition. Blackwell Publishing. 2007.
4. Environmental Microbiology edited by R. Mitchell, J-D Gu. 2nd edition. Wiley-Blackwell. 2009.
5. Environmental Microbiology by R. Maier, I. Pepper, C. Gerba. 2nd edition. Academic Press. 2009.
6. Environmental Microbiology: Principles and Applications by P.K. Jjemba, Science Publishing Inc. 2004.
7. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad, A. Singh. I.K. International. 2007.
8. Environmental Microbiology of Aquatic & Waste systems by N. Okafor. 1stedition, Springer, New York. 2011

SEMESTER 2
CORE COURSE PAPER 6
MB21270 FERMENTATION TECHNOLOGY

Course Objectives:

The course will enable students to apply the learning of microbiology concepts toward the exploitation of microbial populations for industrial and human benefits. The strategies for development of microbial strains, process optimization, designing parameters of a fementor and its type.

Course learning outcomes : By the end of this course the students-

CO1: Will have gained insight on industrially important microbes, recent developments in fermentation processes and various optimization strategies at fermenter level. CO2: Understands the concept of sterilization methods and principles of batch and continuous processes.

CO3: Attains knowledge about designing of industrial strains and various media optimization strategies

CO4: Learns about the design, types of fermenters and various critical components of bioreactors CO5: Is able to describe control parameters, fluid rheology and process constraints in a large scale bioreactor

CO6: Gets introduced to various strategies of product recovery from a fermentation broth CO7: Acquires knowledge about various industrially relevant microbial products and their production process

THEORY COURSE
(4 Credits)

Unit-1	**Introduction to industrial microbiology:** Introduction to microbial products and fermentation processes, sources of industrially important microorganisms, stoichiometric analysis of biochemical reactions, carbon and nitrogen balance, oxidation-reduction principle in fermentation, recent developments in fermentation technology. Batch cultivation, continuous cultivation, multistage chemostat, feedback systems, types of fed-batch cultures, open and closed systems, Monod kinetics of microbial growth, growth and non-growth associated product formation, product formation kinetics and mathematical modelling.	**15 Lectures**
Uni-2	**Sterilization methods and principles:** Media sterilization, mathematical modeling of sterilization processes, Arrhenius equation, Del factor, effect of sterilization on media quality and yield coefficients, batch & continuous sterilization, filter & steam sterilization at industrial scale	**15 Lectures**
Unit-3	**Designing of industrial Strains and media optimization:** Industrially important microorganisms, preservation techniques for microbial cultures, inoculum development, microbial strain improvement, high throughput screening methods, recombinant DNA technology in strain improvement,	**15 Lectures**

	metabolic engineering and flux analysis, media optimization strategies like Plackett–Burman design, Box-Wilson central composite design, response surface methodology.	
Unit-4	**Design and types of fermenters:** Basic components of a fermenter, fermenter construction materials, designing of laboratory and industrial scale fermenters, types of impellers, mechanical seal, types of baffle and spargers, sampler design, foam controller, types of fermenter like stirred tank, bubble column, airlift, hollow fibers chambers, packed beds, fluidized beds, perfusion cultures, photo-bioreactors and animal cell culture bioreactor.	**15 Lectures**

Reference Book

1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition. Butterworth-Heinemann. 2016.
2. Bioprocess Engineering: Basic Concepts by M. L. Shuler, F. Kargi, 2nd edition. Pearson Education India. 2015.
3. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st edition. CRC Press, USA. 2007.
4. Fermentation Microbiology and Biotechnology edited by E.M.T. El-Mansi, C.F. Bryce, A.L. Demain, A.R. Allman. 3rd edition. CRC Press. 2012.
5. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer, HNikaido. 2nd edition. Cambridge University Press. 2007.
6. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley &Sons Ltd. 2007.
7. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R.D. Sindelar, B. Meibohm. 4thEdition. Springer. 2013.

SEMESTER 2
CORE COURSE PAPER 7
MB21280 INDUSTRIAL MICROBIOLOGY

Course Objectives:

The course will enable students to apply the learning of microbiology concepts toward the exploitation of microbial populations for industrial and human benefits. The strategies for process optimization, large scale production and product recovery will be covered for industrially relevant microbial products and therapeutic proteins.

Course learning outcomes : By the end of this course the students-

CO1: Will understand the instruments and their control for maintaining parameters in the fermentation industry

CO2: will understand the processes involved in the separation of a product after fermentation completes

CO3: will exposed to well established commercial fermentation processes.

THEORY COURSE (4 Credits)		
Unit-1	**Bioprocess instrumentation and control parameters:** Measurement of various control parameters in bioreactor like pH, dissolved oxygen, temperature, antifoam, principles of feed-back control, PID control, respiratory quotient, effect of dissolved oxygen on microbial production processes, effect of foam and anti-foam on oxygen transfer, oxygen mass transfer coefficient, measurement of KLa values using sulfite oxidation techniques, gassing-out techniques, fluid rheology: newtonian and non-newtonian fluids- bingham plastic, pseudo plastic, power number, Reynolds number	**15 Lectures**
Uni-2	**Downstream processing of microbial products:** Batch filtration, centrifugation, cell disruption, liquid-liquid extraction, solvent recovery**,** supercritical fluid extraction, various chromatography techniques in product recovery, diafiltration, ultra-filtration and reverse osmosis, drying (lyophilization and spray drying), whole broth processing and crystallization.	**15 Lectures**
Unit-3	**Applications of industrial microbiology-production aspects-I:** Development of heterologous expression platforms like bacteria, yeast, mammalian and insect cells, process optimization of recombinant biopharmaceuticals; industrial enzymes (cellulases, laccase, amylases, biosurfactants, thaumatin, food additives etc.), therapeutic proteins (haemostasis factors, thrombolytic agents, hormones and recombinant vaccines), antibodies (chimaeric and humanized antibodies, antibody fragments).	**15 Lectures**
Unit-4	**Applications of industrial microbiology-production aspects-II:** Microbial transformation process, cell surface display technology, development of biosimilars, good manufacturing practices, intellectual property rights and technology transfer, different phases of clinical trials of therapeutic biomolecules. Basic objective for successful economically viable fermentation process, cost breakdown for well established fermentation processes, market potential of the products, cost aspects of various stages in the processes development including effluent treatment	**15 Lectures**

Reference Book

1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition. Butterworth-Heinemann. 2016.
2. Bioprocess Engineering: Basic Concepts by M. L. Shuler, F. Kargi, 2nd edition. Pearson Education India. 2015.
3. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st edition. CRC Press, USA. 2007.
4. Fermentation Microbiology and Biotechnology edited by E.M.T. El-Mansi, C.F. Bryce, A.L. Demain, A.R. Allman. 3rd edition. CRC Press. 2012.
5. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer, HNikaido. 2nd edition. Cambridge University Press. 2007.
6. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley &Sons

Ltd. 2007.

7. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R.D. Sindelar, B. Meibohm. 4thEdition. Springer. 2013.

SEMESTER 3
CORE COURSE PAPER 8
MB21290 MICROBIAL GENETICS

Course Objectives:

The objective of this course is to understand how microorganisms can be used as tools to understand various biological phenomena. The student will become familiar with methods of transfer of genetic material in bacteria, and will understand the biology of lytic and lysogenic phages. The student will be acquainted with the different modes of gene regulation in bacteria and the importance of bacterial transposition and its applications.

Course learning outcomes : By the end of this course the students-

CO1: Can discuss the importance of mutation analysis, can analyze mutations by complementation and recombination tests, and can design a strategy to create gene replacement in bacteria

CO2: Is able to explain how plasmid copy number is regulated, can differentiate between Hfrstrains and strains carrying F plasmid, and can construct a genetic map of bacterial genome using conjugation-based method

CO3: Is able to compare and contrast generalized versus specialized transduction, knows how to construct genetic linkage maps using two-factor and three factor cross, is able to discuss the basis of natural competence in bacteria.

CO4: Is able to list the events in the lytic and lysogenic phases of lambda phage life cycle and the regulatory factors and events involved.

CO5: Can list the outcomes of transposition events, can design strategies to mutagenize bacteria using transposons, can explain the construction of conditional knockouts

CO6: Can differentiate between positive and negative regulation of gene expression, inducible and repressible systems. Can describe the regulation of the lac, trp, gal,ara and tol operons.

CO7: Will have learnt about the model organisms used in biological studies.

THEORY COURSE
(4 Credits)

Unit-1	**Genetic analysis of bacteria:** Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests & gene replacements. Cloning genes by complementation. Cloning genes by marker rescue.	**15 Lectures**

Uni-2	**Gene transfer and mapping by conjugation:** Basis of fertility in bacteria. Self-transmissible and mobilizable plasmids. Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation. Hfr strains. Mapping bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids – by integrated plasmids, by chromosome mobilization and by creation of prime factors. Transfer systems in gram positive bacteria. Ti plasmid transfer system and its application in creating transgenics.	**15 Lectures**
Unit-3	**Lytic bacteriophages and gene transfer by transformation and transduction:** Lytic development cycle, replication and regulation of expression of genes in phage T4 and phage T7. Natural transformation and competence. Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in *B.subtilis*. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction: T4, lambda phage. Mapping bacterial genes by transduction.	**15 Lectures**
Unit-4	**Transposons, Gene regulation and Model organisms used in genetic studies:** Transposons-Discovery, Classes, regulation of transposition activity, Molecular mechanisms of transposition, Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the *lac*, *gal*, *trp*, *ara*, *tol*operons. Yeast (*Saccharomyces cerevisiae*), fruitfly (*Drosophila melanogaster*), nematode worm (*Caenorhabditis elegans*), mouse (*Mus musculus*), Arabidopsis (*Arabidopsis thaliana*).	**15 Lectures**

Reference Book

1. Molecular Genetics of Bacteria by L. Snyder, J. Peters, T. Henkin, W. Champness. 4th edition. ASM Press. 2013.
2. Fundamental Bacterial Genetics by N. Trun, J. Trempy. 1st edition. Wiley-Blackwell Publishing. 2004.
3. Modern Microbial Genetics edited by U.N. Streips, R.E. Yasbin. 2nd edition. Wiley-Liss Publishers. 2002.
4. Microbial Genetics by S.R. Maloy, J.E. Cronan, Jr., D. Freifelder. 2nd edition. Jones and Bartlett Publishers. 1994.

MB21300: Practical III

Marks: 100 Duration: 60 hours (4 credits)

Course Objectives:

The objective of the course is to familiarize students with techniques involved in studying soil and water microbiology, industrial microbiology and microbial pathogenesis. The student will receive hands-on training in various culturing and molecular techniques for studying microbial diversity and microbial activity in soil. He/she will be acquainted with a variety of water testing methods and get practical training in yeast recombinant system, submerged and solidstate batch fermentations. They will gain expertise in

differentiating pathogens based on cultural methods and MIC determination.

Course Learning Outcomes: The student:

CO1. Is able to determine the basic properties (pH, water holding capacity, moisture content and organic matter content) of the given soil sample

CO2. Is able to measure the microbial activity in the soil by measuring the CO2 evolution, dehydrogenase activity, and nitrate reduction.

CO4. Can perform total plate count with soil samples, calculate the ratio of proteolytic and amylolytic bacteria, isolate fungi present in soil samples and calculate their relative abundance and frequency of occurrence.

CO5. Can test the microbiological quality of water samples from different sources.

CO6. Can set up SSF and SMF for the enzymes cellulase and xylanase using the fungal isolates and estimate the enzyme activities.

Contents:

1. To determine the microbial activity in the soil by measuring the CO2 evolution and study the effect of moisture and organic matter on microbial activity.
2. To determine the dehydrogenase activity in soil by microorganisms.
3. To determine the nitrate reduction in soil by microorganisms.
4. To study the basic properties (pH, water holding capacity, moisture content and organic matter content) of the given soil sample.
5. To perform total plate count with soil samples and calculate the ratio of proteolytic and amylolytic bacteria.
6. To study the microbiological quality of water samples from different sources.
7. To determine the BOD of sewage water.
8. To Determine the COD of given water sample.
9. To determine the acidity and alkalinity of the water sample.
10. To determine the calcium, magnesium and total Hardness of given water sample
11. To set up SSF and SMF for the enzymes cellulase using the fungal isolates and estimate the enzyme activities.

Suggested Readings:

1. Microbiology: A laboratory manual by JG Cappucino, N Sherman. 10th Ed.Pearson. 2014.
2. Environmental Microbiology: A lab manual by I. Pepper, C. Gerba, J. Brendecke. 46th Ed. Academic Press. 2011.

MB21310: Practical IV

Marks: 100 Duration: 60 hours (4 credits)

Course Objectives:

The objective of the course is to familiarize students with techniques involved in studying soil and water microbiology, industrial microbiology and microbial pathogenesis. The student will receive hands-on training in various culturing and molecular techniques for studying microbial diversity and microbial activity in soil. He/she will be acquainted with a variety of water testing methods and get practical training in yeast recombinant system, submerged and solid state batch fermentations. They will gain expertise in differentiating pathogens based on cultural methods and MIC determination.

Course Learning Outcomes: The student:

CO1. Can grow yeast (*S. cerevisiae*) and fungus (*Rhizopus*sp.) in artificial medium and calculate the yield and productivity of the biomass produced.

CO2. Can identify pathogenic bacteria on selective/differential media:

CO3. Can carry out the coagulase test for pathogenicity of *Staphylococcus aureus*

CO4. Is able to perform the microbial water analysis test.

CO5. Can determine the antimicrobial susceptibility testing using an octadisc and minimal inhibitory concentration (MIC) of an antibiotic using an E-test.

CO6. Is able to perform sterility testing of a sample and is acquainted with the resident microflora of skin and oral cavity.

CO7. Is able to identify selected pathogenic fungi viz. *Microsporum*sp., *Candida albicans*, and *Aspergillus* sp. based on their cultural and microscopic characteristics.

Contents:

1. To grow yeast (*S. cerevisiae*) and fungus (*Rhizopus*sp.) in artificial medium and to calculate the yield and productivity of the biomass produced.
2. To study cultural characteristics of pathogenic bacteria on following selective/differential media: TCBS agar; Hektoen Enteric agar; XLD agar; Endo agar; SS agar; DCA agar
3. To identify pathogenic strain of *Staphylococcus aureus* by coagulase test
4. To perform the rapid qualitative (P/A format) and quantitative test (MPN) coliform test.
5. To study antimicrobial susceptibility testing using an octadisc.
6. To determine minimal inhibitory concentration (MIC) of an antibiotic using an E-test.
7. To perform sterility testing of a sample.
8. To study resident microflora of skin.
9. To study resident microflora of oral cavity.

Suggested Readings:

1. Microbiology: A laboratory manual by JG Cappucino, N Sherman. 10th Ed.Pearson. 2014.

2. Environmental Microbiology: A lab manual by I. Pepper, C. Gerba, J. Brendecke. 46th Ed. Academic Press. 2011.