



Anekant Education Society's

**Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
(Empowered Autonomous)**

**Four year B.Sc. Degree Program in Microbiology
(Faculty of Science and Technology)**

**Choice-Based Credit System Syllabus
(2024 Pattern) (As per NEP 2020)
S.Y. BSc. Microbiology
SEM IV**

To be implemented from Academic Year November 2025

Title of the Programme: S.Y.B.Sc. (Microbiology)**Preamble**

Anekant Education Society's Tuljaram Chaturchand College has decided to change the syllabus of various faculties from June, 2023 by taking into consideration the guidelines and provisions given in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcomes for the development of the students. The credit structure and the courses framework provided in the NEP are nationally accepted and internationally comparable.

The rapid changes in science and technology and new approaches in different areas of Microbiology and related subjects, Board of Studies in Microbiology of Tuljaram Chaturchand College, Baramati, Dist.- Pune has prepared the syllabus of S. Y. B. Sc. Microbiology Semester - I as per Choice Based Credit System (CBCS) by following the guidelines of NEP 2020, NCeF, NHEQF, Prof. R.D. Kulkarni's Report, GR of Gov. of Maharashtra dated 20th April and 16th May 2023 and Circular of SPPU, Pune dated 31st May 2023.

Microbiology is a branch of science that studies "Life" taking an example of microorganisms such as bacteria, protozoa, algae, fungi, viruses, etc. These studies integrate cytology, physiology, ecology, genetics and molecular biology, evolution, taxonomy and systematics with a focus on microorganisms; in particular bacteria. The relevance and applications of these microorganisms to the surrounding environment including human life and Mother Nature becomes part of this branch. Since inception of this branch of science, Microbiology has remained a field of actively research and ever expanding in all possible directions; broadly categorized as pure and applied science. Different branches of Pure Microbiology based on taxonomy are Bacteriology, Mycology, Protozoology and Parasitology, Phycology and Virology; with considerable overlap between these specific branches over each other and also with other disciplines of life sciences, like Biochemistry, Botany, Zoology, Cell Biology, Biotechnology, Nanotechnology, Bioinformatics, etc. Areas in the applied Microbial Sciences can be identified as: Medical, Pharmaceutical, Industrial (Fermentation, Pollution

Control), Air, Water, Food and Dairy, Agriculture (Plant Pathology and Soil Microbiology), Veterinary, Environmental (Ecology, Geomicrobiology); and the technological aspects of these areas. Knowledge of different aspects of Microbiology has become crucial and indispensable to everyone in the society. Study of microbes has become an integral part of education and human progress. Building a foundation and a sound knowledge- base of Microbiological principles among the future citizens of the country will lead to an educated, intellectual and scientifically advanced society. Microbiological tools have been extensively used to study different life processes and are cutting edge technologies. There is a continual demand for microbiologists in the work force – education, industry and research. Career opportunities for the graduate students are available in manufacturing industry and research institutes at technical level.

Programme Specific Outcomes (PSOs)

<i>PSO1</i>	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
<i>PSO2</i>	Critical Thinking and Problem solving: Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
<i>PSO3</i>	Social competence: Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibit thoughts and ideas effectively in writing and orally
<i>PSO4</i>	Research-related skills and Scientific temper: Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
<i>PSO5</i>	Trans-disciplinary knowledge: Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem
<i>PSO6</i>	Personal and professional competence: Performing dependently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
<i>PSO7</i>	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
<i>PSO8</i>	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
<i>PSO9</i>	Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.



Anekant Education Society's

Tuljaram Chaturchand College of Art's Science and Commerce, Baramati

(Empowered Autonomous)

Board of Studies in Microbiology

(Academic Year 2025-26 to 2027-2028)

Sr.No.	Name of Members	Designation
1	Dr. Pawar Sunil Trimbak Head & Professor, Department of Microbiology, T. C. College, Baramati	Chairperson
2	Dr. Gajbhiye Milind Hemraj Professor, Department of Microbiology, T. C. College, Baramati	Member
3	Dr. Mrs. Mulay Yogini Ramkrushna Professor, Department of Microbiology, T. C. College, Baramati	Member
4	Mr. Doshi Dhawal Vidyachandra Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
5	Ms. Jagtap Komal Ramchandra Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
6	Ms. Bhosale Priti Chaurangnath Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
7	Ms. Owl Sheetal Pramod Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
8	Ms. Honrao Ruchita Rajkumar Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
9	Ms. Gaikwad Kajal Mahadev	Member

	Assistant Professor, Department of Microbiology, T. C. College, Baramati	
10	Ms. Dhapate Puja Mahadeo Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
11	Ms. Markale Prajakta Dattatray Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
12	Ms. Deokate Nikita Tatyasaheb Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
13	Ms. Jadhav Priti Pradeep Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
14	Ms. Jadhav Sayali Kalidas Assistant Professor, Department of Microbiology, T. C. College, Baramati	Member
15	Dr. Shinde Shubhangi	Vice-Chancellor Nominee Subject Expert from SPPU, Pune
16	Dr. Shinde Abhijeet. B	Subject Expert from Outside the Parent University
17	Dr. Petkar A. V.	Subject Expert from Outside the Parent University
18	Mr. Dhobale Avinash	Representative from industry/corporate sector/allied areas
19	Mr. Baradkar Shreekant	Member of the college Alumni
20	Ms. Gaikwad Payal	UG Student
21	Mr. Mane Yogeshwar	PG Student

Level/Difficulty	Sem	Subject DSC-1				Subject DSC-2	Subject DSC-3	GE/OE	SEC	IKS	AEC	VEC	CC	Total
4.5/100	I	2(T)+2(P)				2(T)+2(P)	2(T)+ 2(P)	2(T)	2 (T/P)	2(T)(Generic)	2(T)	2(T)	--	22
	II	2(T)+2(P)				2(T)+2(P)	2(T)+2(P)	2(P)	2 (T/P)	--	2(T)	2(T)	2(T)	22
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/Internship OR Continue with Major and Minor Continue option: Student will select one subject among the (subject 1, subject 2 and subject 3) as major and other as minor and third subject will be dropped.														
Level/Difficulty	Sem	Credits Related to Major				Minor	--	GE/OE	SEC	IKS	AEC	VEC	CC	Total
		Major Core	Major Elective	VSC	FP/OJT/CEP/RP									
5.0/200	III	4(T)+2(P)	--	2 (T/P)	2(FP)	2(T)+2(P)	--	2(T)	--	2(T)	2(T)	--	2(T)	22
	IV	4(T)+2(P)	--	2 (T/P)	2(CEP)	2(T)+2(P)	--	2(P)	2 (T/P)	--	2(T)	--	2(T)	22
Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4credits core NSQF course/Internship OR Continue with Major and Minor														
5.5/300	V	8(T)+4(P)	2(T)+2(P)	2 (T/P)	2(FP/CEP)	2(T)	--	--	--	--	--	--	--	22
	VI	8(T)+4(P)	2(T)+2(P)	2 (T/P)	4 (OJT)	--	--	--	--	--	--	--	--	22
Total 3Years		44	8	8	10	18	8	8	6	4	8	4	6	132
Exit option: Award of UG Degree in Major with 132 credits OR Continue with Major and Minor														
6.0/400	VII	6(T)+4(P)	2(T)+2 (T/P)	--	4(RP)	4(RM)(T)	--	--	--	--	--	--	--	22
	VIII	6(T)+4(P)	2(T)+2 (T/P)	--	6(RP)	--	--	--	--	--	--	--	--	22
Total 4Years		64	16	8	22	22	8	8	6	4	8	4	6	176
Four Year UG Honours with Research Degree in Major and Minor with 176 credits														
6.0/400	VII	10(T)+4(P)	2(T)+2 (T/P)	--	--	4(RM) (T)	--	--	--	--	--	--	--	22
	VIII	10(T)+4(P)	2(T)+2 (T/P)	--	4 (OJT)	--	--	--	--	--	--	--	--	22
Total 4Years		72	16	8	14	22	8	8	6	4	8	4	6	176
Four Year UG Honours Degree in Major and Minor with 176 credits														
T = Theory P = Practical DSC = Discipline Specific Course OE = Open Elective SEC = Skill Enhancement Course IKS = Indian Knowledge System AEC = Ability Enhancement Course VEC = Value Education Course CC = Co-curricular Course VSC= Vocational Skill Course OJT= On Job Training CEP= Community Engagement Project FP= Field Project RP= Research Project														

Anekant Education Society's**Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
(Autonomous)****NEP-2.0****Course Structure for F.Y.B.Sc. Microbiology (2024 Pattern as per NEP-2020)**

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
I	DSC-I (General)	-101-GEN		T	02
		-102-GEN		P	02
	DSC-II (General)	-101-GEN		T	02
		-102-GEN		P	02
	DSC-III (General)	MIB-101-GEN	Introduction to Microbiology	T	02
		MIB-102-GEN	Practical Course I	P	02
	Open Elective (OE)	MIB-103-OE	The Microbial World	T	02
	Skill Enhancement Course (SEC)	MIB-104-SEC	Skills in Microbiology I	P	02
	Ability Enhancement Course (AEC)	ENG-104-AEC		T	02
	Value Education Course (VEC)	ENV-105-VEC		T	02
	Generic Indian Knowledge System (GIKS)	GEN-106-IKS		T	02
	Total Credits Semester-I				22
	DSC-I (General)	-151-GEN		T	02

II		-152-GEN		P	02
	DSC-II (General)	-151-GEN		T	02
		-152-GEN		P	02
	DSC-III (General)	MIB-151-GEN	Fundamental Microbiology	T	02
		MIB-152-GEN	Practical Course II	P	02
	Open Elective (OE)	MIB-153-OE	Basic Microbiological Practices	P	02
	Skill Enhancement Course (SEC)	MIB-154-SEC	Skills in Microbiology II	P	02
	Ability Enhancement Course (AEC)	ENG-154-AEC		T	02
	Value Education Course (VEC)	COS-155-VEC		T	02
	Co-curricular Course (CC)	YOG/PES/CU L/NSS/NCC-156-CC	To be selected from the CC Basket	T	02
	Total Credits Semester-II				22
	Cumulative Credits Semester I + Semester II				44

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Course Structure for S.Y. B.Sc. (2024 Pattern)

Sem	Course Type	Course Code	Course Title	Theory /Practical	Credits
III	Major Mandatory	MIB-201-MRM	Basic Biochemistry and Bacterial Cytology	Theory	02
	Major Mandatory	MIB-202-MRM	Bacterial Genetics	Theory	02
	Major Mandatory	MIB-203-MRM	Practical Course III	Practical	02
	Vocational Skill Course (VSC)	MIB-204-VSC	Practical Course based on Air and Water Microbiology	Practical	02
	Field Project (FP)	MIB-205-FP	Field Project	Practical	02
	Minor	MIB-206-MN	Cell Organisation and Biochemistry	Theory	02
	Minor	MIB-207-MN	Practical Course based on Cell Organisation and Biochemistry	Practical	02
	Open Elective (OE)	MIB-208-OE	Human Health and Microbes	Theory	02
	(IKS) Indian Knowledge System (Subject specific)	MIB-209-IKS	Ethno-Microbiology	Theory	02
	Ability Enhancement Course (AEC)	MAR-210-AEC HIN-210-AEC SAN-210-AEC		Theory (Any one)	02
	Co-curricular Course (CC)	YOG/PES/CUL/ NSS/NCC-211-CC	To be continued from the semester II		02
				Total Credits (Semester-III)	22
IV	Major Mandatory	MIB-251-MRM	Bacterial Systematics	Theory	02

	Major Mandatory	MIB-252-MRM	Bacterial Physiology	Theory	02
	Major Mandatory	MIB-253-MRM	Practical Course IV	Practical	02
	Vocational Skill Course (VSC)	MIB-254-VSC	Air and Water Microbiology	Theory	02
	Community Engagement Project (CEP)	MIB-255-CEP	Community Engagement Project	Practical	02
	Minor	MIB-256-MN	Water & waste water treatment	Theory	02
	Minor	MIB-257-MN	Practical Course based on Water Microbiology	Practical	02
	Open Elective (OE)	MIB-258-OE	Practical Course based on Human Health and Microbes	Practical	02
	Skill Enhancement Course (SEC)	MIB-259-SEC	Dairy Microbiology	Practical	02
	Ability Enhancement Course (AEC)	MAR-260-AEC HIN-260-AEC SAN-260-AEC		Theory (Any one)	02
	Co-curricular Course (CC)	YOG/PES/CUL/ NSS/NCC-261-CC	To be continued from the semester III		02
				Total Credits (Semester -IV)	22
				Total Credits (Semester III + IV)	44

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc Microbiology
Programme Code	: USMI
Class	: S.Y.B.Sc.
Semester	: IV
Course Type	: Major Mandatory (Theory)
Course Code	: MIB-251- MRM
Course Title	: Bacterial Systematics
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

1. To understand the fundamental principles underlying bacterial taxonomy and classification.
2. To comprehend the concept of species, taxa, and strain within bacterial classification systems.
3. To familiarize students with the structure and organization of Bergey's Manual of Systematic Bacteriology as a primary reference for bacterial classification.
4. To explore the general characteristics and classification of various bacterial groups including Fungi, Eubacteria, Archaeobacteria, Mycoplasma, and Rickettsia.
5. To introduce students to chemotaxonomy as a method for classifying bacteria based on chemical composition.
6. To provide an overview of numerical taxonomy techniques used in bacterial systematics for quantitative analysis and classification.
7. To examine the genetic basis of bacterial taxonomy, focusing on G + C content, DNA hybridization, and base sequence similarity using the 16s rRNA databank.

Course Outcomes:

- CO1 Students will be able to apply principles of bacterial taxonomy and classification to classify various bacterial species accurately.
- CO2 Students will demonstrate a clear understanding of the distinctions between species, taxa, and strains within bacterial classification systems.
- CO3 Students will be proficient in navigating Bergey's Manual of Systematic Bacteriology for reference and classification purposes.
- CO4 Students will be able to identify and differentiate between different groups of bacteria, including Fungi, Eubacteria, Archaeobacteria, Mycoplasma, and Rickettsia.
- CO5 Students will develop the skills to utilize chemotaxonomy methods effectively in bacterial classification based on chemical composition.
- CO6 Students will be able to apply numerical taxonomy techniques to quantitatively analyze and classify bacterial populations.

- CO7 Students will gain competence in analyzing the genetic basis of bacterial taxonomy, including G + C content, DNA hybridization, and base sequence similarity using the 16s rRNA databank.

Credit		Learning & Teaching Points	Teaching Hours
I	Unit 1	Principles of Bacterial Systematics	15
		1. Introduction to bacterial taxonomy	1
		2. Natural System of Classification,	1
		3. Classification and Linnaean System	1
		4. Haeckel's three kingdom of classification	2
		5. Whittaker's five kingdom classification	3
		6. Three domain concept of Carl Woese.	2
		7. Introduction to Bergey's manual of determinative bacteriology	1
		8. Outline of bacterial classification as per Bergey's manual of systematic bacteriology	2
		9. Concept of species, taxa, strain	2
II	Unit 1	Chemotaxonomy & Numerical taxonomy	6
		1. Chemotaxonomy on the basis of: a) Cell wall composition b) Lipid composition c) Fatty acid composition d) Cytochrome e) Isoprenoid quinones f) Protein profile g) Amino acid sequences	4
		2. Numerical taxonomy A) Definition, procedure- collection of data, tabulation of data, arrangement of data, plotting a graph. (dendogram)	2
	Unit 2	Genetic basis of taxonomy	9
		1. G + C Content Definition, significance, variation among species, and limitations.	3
		2. DNA Hybridization Principle, method, percentage similarity for species identification, applications and limitations.	3

		3. Gene Sequence Similarity – 16S rRNA Sequencing Principle, steps, applications, advantages, and limitations.	3
Total			30

References :

1. Bergey D. H. & Holt J. G. (1994) Bergey's Manual of Determinative Bacteriology. 9th Edition. Lippincott Williams & Wilkins. (Unit I)
2. Garrity G. M. (2005) Bergey's Manual of Systematic Bacteriology. 2nd Edition. (Vols. 1 – 4). Williams & Wilkins. (Unit I)
3. Madigan M. T., Martinko J. M. (2006) Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc. (Unit I, II& III)
4. Prescott L. M., Harley J. P. and Klein D. A. (2005) Microbiology, 6th Edition. MacGraw Hill Companies Inc. (Unit II)
5. Priest F. G. & Brian Austin. (1993) Modern Bacterial Taxonomy. Edn 2, Springer. (Unit I)

Mapping of course outcomes and programme outcomes:

Class: SYBSc (Sem IV)
Course: Bacterial Systematics

Subject: Microbiology
Course code: MIB-251-MRM

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcomes (COs)	Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	2	3	3	2	3	3	2	2	2	2	2
CO2	3	2	1	3	2	1	3	2	2	1	1	2	1
CO3	3	2	2	3	2	2	3	3	3	2	1	2	2
CO4	3	2	2	3	2	2	3	3	2	2	2	2	2
CO5	3	3	2	3	3	2	3	3	3	2	2	2	2
CO6	3	3	2	3	3	2	3	3	3	2	2	3	2
CO7	3	3	2	3	3	2	3	3	3	2	2	3	2

Justification for the mapping**PO1: Comprehensive Knowledge and Understanding**

- **CO1, CO2, and CO3** ensure a strong understanding of bacterial taxonomy, classification principles, and the use of Bergey's Manual.
- **CO4, CO5, and CO7** extend knowledge to include fungal, bacterial, and archaeal classification.

PO2: Practical, Professional, and Procedural Knowledge

- **CO5, CO6, and CO7** involve chemotaxonomy, numerical taxonomy, and genetic analysis, all of which require procedural expertise.
- **CO3** involves proficiency in using Bergey's Manual, an essential reference tool.

PO3: Entrepreneurial Mindset and Knowledge

- CO1, CO3, and CO5 relate to biotechnology applications in microbial identification and classification, useful for industries like pharmaceuticals and diagnostics.

PO4: Specialized Skills and Competencies

- CO1, CO3, and CO6 develop the ability to classify bacteria using numerical taxonomy and genetic methods.
- CO5 and CO7 provide chemotaxonomic and molecular techniques essential for microbial research.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning

- CO1, CO4, CO5, and CO6 require problem-solving skills in classifying bacteria based on morphology, biochemical properties, and genetics.

PO6: Communication Skills and Collaboration

- CO1 and CO3 involve effective communication of taxonomic data and classification results in scientific reports and discussions.

PO7: Research-related Skills

- CO5, CO6, and CO7 require research abilities in microbial systematics, including DNA sequencing and molecular analysis.
- CO3 involves data interpretation from Bergey's Manual.

PO8: Learning How to Learn Skills

- CO3, CO4, CO5, and CO6 promote self-learning through exploration of taxonomic methods, bioinformatics, and molecular tools.

PO9: Digital and Technological Skills

- CO6 and CO7 use computational methods for analyzing bacterial genomes and taxonomy databases (e.g., 16S rRNA databank).

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- CO1 and CO4 relate to understanding microbial diversity across different ecological and cultural contexts.

PO11: Value Inculcation and Environmental Awareness

- CO4 and CO7 promote awareness of microbial diversity's role in ecosystems and environmental conservation.

PO12: Autonomy, Responsibility, and Accountability

- CO6 and CO7 encourage independent research and responsible scientific analysis in taxonomy.

PO13: Community Engagement and Service

CO1 and CO3 support engagement in microbiology outreach, such as bacterial identification in health.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc. Microbiology
Programme Code	: USMI
Class	: S. Y. B.Sc.
Semester	: IV
Course Type	: Major Mandatory (Theory)
Course Code	: MIB-252-MRM
Course Title	: Bacterial Physiology
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:	
1	To understand the fundamental types of metabolic reactions in bacteria, including catabolism and anabolism, and their role in microbial physiology.
2	To explain the nature, properties, and mechanisms of action of enzymes, including concepts such as activation energy, energy hill, transition state, and enzyme-substrate interaction models.
3	To examine the structure and function of enzyme active sites, cofactors, coenzymes, and ribozymes, and their significance in microbial metabolism.
4	To develop knowledge of key cofactors involved in bacterial metabolism, including vitamins and metal ions, and their biochemical roles.
5	To introduce the principles of enzyme kinetics, including the Michaelis-Menten equation, kinetic plots, and types of enzyme inhibition.
6	To explore the sources of nutrients and mechanisms of nutrient uptake in bacteria, including passive and active transport systems and group translocation.
7	To analyze the enzymatic degradation of carbohydrates by bacteria and understand the central metabolic pathways such as glycolysis, pentose phosphate pathway, Entner-Doudoroff pathway, and TCA cycle.
Course Outcomes:	
CO1	Students will be able to differentiate between catabolic and anabolic metabolic reactions and describe their importance in bacterial growth and maintenance.

CO2	Students will be able to explain how enzymes accelerate metabolic reactions by lowering activation energy and stabilizing transition states.
CO3	Students will identify enzyme components (apoenzyme, coenzyme, prosthetic groups, cofactors) and describe their roles in catalysis.
CO4	Students will be proficient in interpreting enzyme kinetic data using Michaelis-Menten and Lineweaver-Burk plots and understand enzyme inhibition mechanisms.
CO5	Students will recognize various vitamin-derived cofactors and metal ions essential for microbial enzymatic reactions and their biochemical functions.
CO6	Students will describe the architecture of bacterial cell membranes and detail the mechanisms of nutrient uptake, including passive and active transport.
CO7	Students will understand the enzymatic processes involved in carbohydrate degradation in bacteria and describe the major pathways of central metabolism.

Credit No.	Topics	Lectures
I	Metabolic reactions	15
	Unit 1: Biocatalyst	
	Types of metabolic reactions in bacteria: ➤ Catabolism ➤ Anabolism How enzymes affect the rate of metabolic reactions? ➤ Transition state ➤ Activation energy	01
	Introduction to Enzymes: ➤ Nature and properties of enzymes, coenzymes, apoenzyme, prosthetic groups and cofactors, ribozyme ➤ Structure of active site; common amino acids at active site	01
	Models for catalysis: ➤ Lock and key	02

	➤ Induced fit	
	Role of cofactors in metabolism: Occurrence, Structure and Biochemical functions of the following -: ➤ Nicotinic Acid (Niacin) and the Pyrimidine nucleotides ➤ Riboflavin (Vitamin B2) and the Flavin nucleotides ➤ Thiamine (Vitamin B1) and Thiamine Pyrophosphate ➤ Pantothenic acid and coenzyme-A ➤ Pyridoxal phosphate (Vitamin B6) ➤ Metal ions	04
	Unit 2: Enzyme Kinetics	
	Introduction to enzyme kinetics: ➤ Law of mass action ➤ First, Second and Zero order reaction ➤ Concept and use of initial velocity	01
	Enzyme kinetics parameters of single substrate enzyme catalysed reaction: ➤ Michaelis Menten equation ➤ Brigg's Haldane modification of Michaelis Menten equation ➤ Michaelis Menten plot ➤ Definition and significance of K_m, V_{max}	04
	Different plots for plotting Kinetic data: ➤ Lineweaver and Burk plot ➤ Eadie Hofstee plot	01
	Concepts and types of Enzyme Inhibitions: ➤ Competitive inhibition ➤ Uncompetitive inhibition ➤ Non-competitive inhibition	01

	➤ Irreversible inhibition	
II	Nutrient uptake and degradation of carbohydrates in bacteria	15
	Unit 1: Nutrient sources and uptake	
	Carbon, nitrogen, and energy sources for bacteria along with its role in cell growth: ➤ Carbon Sources: Organic compounds (heterotrophs), Inorganic compounds (autotrophs) ➤ Nitrogen Sources: Organic nitrogen, Inorganic nitrogen ➤ Energy Sources: Phototrophs, Chemotrophs	01
	Nutrient uptake in bacteria: ➤ Composition and Architecture of cell Membrane ➤ Passive transport: Diffusion, Osmosis, Facilitated transport ➤ Active transport: Primary and secondary active transport systems in bacteria ➤ Group translocation of sugars in bacteria	01 02 02 01
	Unit 2: Degradation of carbohydrates in bacteria	
	Carbohydrate-active enzymes (CAZymes): ➤ Glycoside Hydrolases (Cellulases, xylanases, amylases, chitinases, and glucosidases) ➤ Polysaccharide Lyases (PL) ➤ Carbohydrate Esterases (CE) ➤ Auxiliary Activities (AA) enzymes	02
	Central metabolic pathways: ➤ Glycolysis ➤ Pentose Phosphate Pathways ➤ Entner-Doudoroff (ED) pathway ➤ TCA	06

References:	
Topic (from syllabus)	Reference Book(s)
Types of metabolic reactions in bacteria	❖ "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, by Wiley-Liss, Inc.
How enzymes affect metabolic reactions (Activation energy, Energy hill, Transition state)	❖ "Biochemistry" by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 10th Edition, Published by Macmillan ❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd
Introduction to enzymes (nature, properties, coenzymes, apoenzyme, prosthetic groups, cofactors, ribozyme)	❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd ❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co
Structure of active site and common active site amino acids	❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co ❖ "Biochemistry" by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 10th Edition, Published by Macmillan
Models for catalysis (Lock and Key, Induced fit)	❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd ❖ "Biochemistry" by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 10th Edition, Published by Macmillan

References:	
Topic (from syllabus)	Reference Book(s)
Role of cofactors in metabolism (Niacin, Riboflavin, Thiamine, Pantothenic acid, Pyridoxal phosphate, Metal ions)	❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co ❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd
Enzyme kinetics (Law of mass action, reaction orders, initial velocity, Michaelis Menten equation, Km, Vmax)	❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co ❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd
Different kinetic plots (Lineweaver-Burk, Eadie-Hofstee)	❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd ❖ "Biochemistry" by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 10th Edition, Published by Macmillan
Concepts and types of enzyme inhibition	❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co ❖ "Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Trevor Palmer, 2nd Edition, published by Woodhead publishing ltd
Nutrient sources and uptake in bacteria (Carbon, Nitrogen, Energy sources), Bacterial cell membrane composition and architecture	❖ "Brock Biology of Microorganisms" by Michael T. Madigan, Kelly S. Bender, et al., 15th Edition, Published by Pearson ❖ "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, by Wiley-Liss, Inc.

References:	
Topic (from syllabus)	Reference Book(s)
Passive and Active transport systems in bacteria	❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co ❖ "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, by Wiley-Liss, Inc.
Group translocation of sugars in bacteria	❖ "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, by Wiley-Liss, Inc. ❖ "Principles of Microbiology" by Ronald M. Atlas, 2nd Edition, Published by Mcgraw-Hill Book Company
Carbohydrate-active enzymes (Glycoside Hydrolases, Polysaccharide Lyases, Esterases)	❖ "Brock Biology of Microorganisms" by Michael T. Madigan, Kelly S. Bender, et al., 15th Edition, Published by Pearson
Central metabolic pathways (Glycolysis, Pentose Phosphate Pathway, Entner-Doudoroff pathway, TCA cycle)	❖ "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox, 8th edition, Published by W H Freeman & Co ❖ "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, by Wiley-Liss, Inc.

Mapping of course outcomes and programme outcomes:	
Class: S. Y. B.Sc. (Sem IV)	Subject: Microbiology
Course: Bacterial Physiology	Course code: MIB-252-MRM
Weightage: 1 = weak or low relation, 2 = Moderate or partial relation, 3 = Strong or direct relation	

	Program Outcomes
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Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	2	3	1	2	2	1	1	2	2	1
CO2	3	2	1	3	3	2	3	2	1	1	1	2	1
CO3	3	3	1	3	2	1	3	2	2	1	1	2	1
CO4	2	3	1	3	3	2	3	3	2	1	1	3	1
CO5	3	3	2	3	2	1	2	2	2	1	1	2	1
CO6	3	3	2	3	2	2	2	2	2	2	1	2	1
CO7	3	3	2	3	3	2	2	2	2	1	1	3	1

Justifications:

- CO1 is strongly linked to PO1 (comprehensive knowledge) and PO5 (application and problem-solving) because understanding catabolic and anabolic reactions is foundational and crucial for practical biochemical processes.
- CO2 strongly relates to PO1, PO4 (specialized skills), PO5, and PO7 (research skills) due to explaining enzymatic acceleration requiring deep conceptual and applied knowledge.
- CO3 emphasizes PO1, PO2 (practical knowledge), PO4, and PO7 as enzyme components involve both theoretical and procedural understanding.
- CO4 focuses on PO2, PO4, PO5, PO7, and PO8 (learning how to learn) since enzyme kinetics and data interpretation are technical and analytical skills.
- CO5 connects with PO1, PO2, and PO4 due to the biochemical role of cofactors requiring specialized knowledge and practical familiarity.
- CO6 is related to PO1, PO2, PO4, and PO6 (communication and collaboration) since nutrient uptake involves cell biology concepts and understanding processes communicable in teamwork.
- CO7 strongly maps to PO1, PO2, PO4, PO5, and PO12 (autonomy and responsibility) as carbohydrate metabolism is a complex area requiring independent study and integration of knowledge.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc Microbiology
Programme Code	: USMI
Class	: S.Y.B.Sc.
Semester	: IV
Course Type	: Major Mandatory (Practical)
Course Code	: MIB-253- MRM
Course Title	: Practical Course IV
No. of Credits	: 02
No. of Practicals	: 15

Course Objective

1. Understand the principles of bacterial classification and identification using morphological, cultural, and biochemical characteristics.
2. Learn and perform biochemical tests (e.g., IMViC, catalase, oxidase, gelatinase, fermentation tests) for differentiating bacterial species.
3. Develop skills in isolation and purification of bacteria from environmental sources such as soil and air.
4. Analyze bacterial growth patterns and calculate growth parameters such as generation time and specific growth rate.
5. Investigate bacterial metabolism through the study of sugar utilization, nitrogen source utilization, and enzymatic activities.
6. Apply standard microbiological techniques to identify unknown bacterial isolates using *Bergey's Manual of Determinative Bacteriology*.
7. Construct and interpret standard graphs for quantification of reducing sugars and proteins to support physiological studies.

Course Outcomes (COs)

CO1: Classify and identify bacteria up to the genus level using morphological, staining, and biochemical data.

CO2: Perform and interpret biochemical tests to distinguish bacterial species based on metabolic capabilities.

CO3: Isolate and characterize bacteria with specific physiological traits (e.g., starch-degrading, cellulase-producing).

CO4: Generate, plot, and analyze bacterial growth curves to determine growth kinetics and physiological states.

CO5: Demonstrate understanding of bacterial nutrient utilization and enzymatic activities in metabolic processes.

CO6: Use Bergey's Manual effectively for taxonomic identification and differentiation of bacterial isolates.

CO7: Prepare standard curves for sugars and proteins and use them for quantitative biochemical estimations.

Pr. No	Topic & Learning Points	Teaching Hours
	Bacterial Systematics and Bacterial Physiology	
	Biochemical Tests for Identification of bacteria:	
1	Sugar utilization test (minimal medium + sugar)	4
2	Sugar fermentation test (any four sugars)	4
3	IMVIC	4
4	Oxidative-fermentation test	4
5	Oxidase & Catalase	4
6	Gelatinase	4
7	Urease	4
8	Study of utilization of different Nitrogen (organic and inorganic) sources by bacteria.	4
9	Identification of Any one bacterial isolate at least up to genus level from Soil or air by using Bergey's manual. (Preferably pigmented bacteria)	4
10	Study and plot the growth curve of <i>E.coli</i> by turbidimetric method	4
11	Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.	4
12	Isolation of cellulase producing bacteria from soil.	4
13	Isolation of starch degrading bacteria from soil	4
14	Estimation of any one reducing sugar	4

15	Estimation of Protein	4
Total		60

References:

- 1) Bergey D. H. & Holt J. G. (1994) Bergey's Manual of Determinative Bacteriology. 9th Edition. Lippincott Williams & Wilkins. (Unit I)
- 2) Garriety G. M. (2005) Bergey's Manual of Systematic Bacteriology. 2nd Edition. (Vols. 1-4) Williams & Wilkins. (Unit I)
- 3) Dube H.C. and Bilgrami. K.S.(1976) Text book of modern pathology. Vikas publishing house. New Delhi.
- 4) Daniel Lim., Microbiology, 2nd Edition; McGraw-Hill Publication
- 5) Tortora G.J., Funke B.R., Case C.L. (2006) Microbiology: An Introduction. 8 th Edition.
- 6) Pelzar M. J., Chan E. C. S., Krieg N. R.(1986) Microbiology. 5th Edition, McGraw-Hill Publication
- 7) Hans G. Schlegel (1993) General Microbiology, 8th Edition, Cambridge University Press
- 8) Martin Frobisher (1937) Fundamentals of Microbiology, 8th Edition, Saunders, Michigan University press.
- 9) Cappuccino, J.G., & Welsh, C. (2019). *Microbiology: A Laboratory Manual* (11th ed.). Pearson Education.
- 10) Aneja, K.R. (2016). *Experiments in Microbiology, Plant Pathology and Biotechnology* (5th ed.). New Age International Publishers.
- 11) Nelson, D.L., & Cox, M.M. (2017). *Lehninger Principles of Biochemistry* (7th ed.). W.H. Freeman.

For understanding enzyme kinetics (K_m and V_{max}), metabolism, and microbial enzyme systems.

- 12) Trevor Palmer (2001). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*. Horwood Publishing.

Good for practical enzyme assays and calculations related to kinetics.

Mapping of course outcomes and programme outcomes:

Class: SYBSc (Sem IV)

Subject: Microbiology

Course: Practical Course IV**Course code: MIB-253-MRM**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcome	Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	2	3	2	2	3	2	2	1	1	3	1
CO2	3	3	2	3	3	2	3	2	2	1	1	3	1
CO3	3	3	2	3	3	2	3	3	2	1	2	3	1
CO4	3	3	2	3	3	2	3	3	3	1	2	3	1
CO5	3	3	2	3	3	2	3	3	2	1	2	3	1
CO6	3	3	2	3	2	2	3	2	2	1	1	3	1
CO7	3	3	2	3	3	2	3	3	3	1	2	3	1

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding: This course is based on the application of microbiological techniques, which requires a deep understanding of bacterial growth, identification methods, and biochemical tests. Understanding bacterial systematics, growth dynamics, and metabolic pathways aligns directly with the goal of comprehensive knowledge. Hence, PO1 has a strong relationship with CO1, CO2, CO3, CO4, CO5, CO6 and CO7.

PO2: Practical, Professional, and Procedural Knowledge: The course focuses heavily on practical microbiology techniques such as bacterial cultivation, growth monitoring, biochemical testing, and bacterial identification. Each CO requires performing laboratory procedures, making PO2 a strongly related outcome to the entire course CO1, CO2, CO3, CO4, CO5, CO6 and CO7.

PO3: Entrepreneurial Mindset and Knowledge: While entrepreneurship is not a core focus, understanding bacterial growth and metabolic processes can have entrepreneurial applications in biotechnology, pharmaceuticals, and environmental industries. This relationship is moderate, as students gain knowledge that could later support entrepreneurial ventures. Hence, PO3 has a moderate relationship with CO1, CO2, CO3, CO4, CO5, CO6, CO7.

PO4: Specialized Skill and Competencies: The course develops specialized skills in microbiology, such as mastering techniques for bacterial growth analysis, enzymatic testing,

and bacterial classification. Each CO contributes to honing technical expertise, making PO4 strongly related to every course outcome CO1, CO2, CO3, CO4, CO5, CO6 and CO7.

PO5: Capacity for Application, Problem Solving, and Analytical Reasoning: Students will be required to apply their theoretical knowledge to solve problems such as determining growth parameters, interpreting biochemical test results, and analyzing the effects of environmental factors on bacterial growth. This makes PO5 strong related to CO2, CO5 and CO7.especially those focused on experimental analysis and data interpretation

PO6: Communication Skills and Collaboration: While communication skills are crucial in documenting experimental results and collaborating in team-based laboratory settings, this is not the primary focus of the course. The course emphasizes laboratory work, but moderate collaboration and effective communication are still necessary for discussing findings and troubleshooting experiments. Thus, PO6 has a moderate relationship with CO1, CO2, CO3, CO4, CO5, CO6, CO7.

PO7: Research-Related Skills: The course emphasizes research-related skills as students design and conduct experiments, analyze bacterial growth data, and perform biochemical tests. Students will gain hands-on experience in scientific inquiry, making PO7 highly Strong related to CO1, CO2, CO3, CO4, CO5, CO6, CO7.

PO8: Learning How to Learn Skills:The course provides students with an opportunity to develop independent learning skills as they apply theoretical knowledge to experimental settings. While not the main focus, students will learn how to adapt and improve their techniques and understanding of microbiological concepts, thus fostering learning how to learn. This PO has a moderate to strong relationship with the CO3, CO7.

PO9: Digital and Technological Skills Although the course involves the use of digital tools (e.g., spectrophotometers, data analysis software), the primary focus is on microbiological techniques rather than technological innovation. Thus, PO9 has a moderate relationship with the CO4, CO7 primarily related to data collection and analysis.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

This PO has limited relevance to the course, as the primary focus is on technical and procedural aspects of microbiology. While students may encounter diverse working environments, the course does not explicitly emphasize multicultural competence or empathy. Therefore, PO10 has a weak relationship with CO1, CO2, CO3, CO4, CO5, CO6, CO7.

PO11: Value Inculcation and Environmental Awareness Environmental factors such as the impact of nitrogen and carbon sources on bacterial growth can foster some level of environmental awareness. However, the course's focus is primarily on technical microbiological skills, making the relationship to value inculcation and environmental awareness relatively weak. Hence, PO11 has a weak to moderate relationship with the CO3, CO5.

PO12: Autonomy, Responsibility, and Accountability The course requires students to take responsibility for their experimental procedures, ensuring accuracy in measurements and results. Autonomy in conducting experiments is important, though students are guided through structured experiments. Hence, PO12 has a strong relationship with the CO1, CO2, CO3, CO4, CO5, CO6, CO7.

PO13: Community Engagement and Services

The course focuses on technical skills development and does not directly engage students with the community. While bacterial knowledge could eventually benefit community-related fields, this course does not emphasize community engagement directly. Therefore, PO13 has a weak relationship with CO1, CO2, CO3, CO4, CO5, CO6, CO7.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc Microbiology
Programme code:	: USMI
Class	: S.Y. B.Sc.
Semester	: IV
Course Type	: Vocational Skill Course (VSC)
Course Code	: MIB-254-VSC
Course Title	: Air and Water Microbiology
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

1. Introducing students to microbial ecology principles, highlighting the distinctive features of microbial life in air and water environments.
2. Exploring the range of microorganisms present in air and water, encompassing bacteria, fungi, viruses, and other microbial entities.
3. Focusing on the microbiology of both natural and engineered water systems, spanning drinking water, wastewater, and aquatic ecosystems, and its impact on public health.
4. Delving into air microbiology, covering aspects of indoor and outdoor air quality, microbial aerosols, and their influence on human health and the environment.
5. Introducing methodologies for monitoring and analyzing microbial communities in air and water, including sampling techniques, laboratory procedures, and data analysis.
6. Assessing the influence of microbial communities on air and water quality, including their involvement in pollution, remediation efforts, and sustainability.
7. Exploring pertinent regulations and guidelines concerning air and water quality, particularly those governing microbial contamination and its management.

Course Outcomes :

CO1: Students will grasp the principles of microbial ecology, emphasizing the distinct characteristics of microbial life within air and water environments.

CO2: Students will investigate the array of microorganisms present in air and water, encompassing bacteria, fungi, viruses, and other microbial entities.

CO3: Concentrating on the microbiology of both natural and engineered water systems, including drinking water, wastewater, and aquatic ecosystems, and its impact on public health.

CO4: Students will explore the microbiology of air, encompassing aspects of indoor and outdoor air quality, microbial aerosols, and their impact on human health and the environment.

CO5: Students will be introduced to techniques for monitoring and analyzing microbial communities in air and water, covering sampling methods, laboratory procedures, and data analysis.

CO6: Evaluate the influence of microbial communities on air and water quality, encompassing their role in pollution, remediation strategies, and sustainability efforts.

CO7: Investigate pertinent regulations and guidelines associated with air and water quality, particularly those governing microbial contamination and its management.

Credit		Topic & Learning Points	Teaching Hours
I	Unit 1	Introduction to Air Microbiology	15
		1. Air flora: Transient nature of air flora	1
		2. Droplet, droplet nuclei, and aerosols	2
		3. Factors affecting microbial survival in air	1
		4. Methods of Air sampling and types of air samplers: i. Impaction on solids ii. Impingement in liquid iii. Sedimentation iv. Centrifugation	4
		5. Air pollution: Chemical pollutants, their sources in air and effects on human health.	2
		6. Air sanitation: Physical methods : HEPA filtration, UV radiation , Chemical methods: Ozone, Vaporized hydrogen peroxide (VHP)	4
		7. Air borne infections & their control prevention	1
II	Unit 1	Introduction to Water Microbiology:	15
		1. Types of water: surface, ground, stored, distilled, mineral and demineralized water	1
		2. Bacteriological standards of potable water:	2

		Maharashtra pollution control board (MPCB), Central pollution control board (CPCB), Bureau of Indian standards (BIS), World health Organization (WHO)	
		3. Indicators of faecal pollution: i. <i>Escherichia coli</i> ii. <i>Bifidobacterium</i> iii. <i>Streptococcus faecalis</i> iv. <i>Clostridium perfringens</i>	3
		4. Water Purification methods: Physical methods & Chemical methods:	2
		5. Physico-Chemical analysis of water: Colour, Odour, Temperature, Dissolve Oxygen (DO), Total Solids (TS) , Total Suspended Solids (TSS), pH	2
		6. Most Probable Number (MPN) Test: i. Presumptive ii. Confirmed iii. Completed iv. Eijkman's Test	3
		7. Membrane Filtration Technique	2
Total			30

References:

- 1) Daniel Lim., Microbiology, 2nd Edition; McGraw-Hill Publication
- 2) Tortora G.J., Funke B.R., Case C.L. (2006) Microbiology: An Introduction. 8th Edition.
- 3) Pelzar M. J., Chan E. C. S., Krieg N. R.(1986) Microbiology. 5th Edition, McGraw-Hill Publication
- 4) Hans G. Schlegel (1993) General Microbiology, 8th Edition, Cambridge University Press
- 5) Martin Frobisher (1937) Fundamentals of Microbiology, 8th Edition, Saunders, Michigan University press

6) Standard Methods for the Examination of Water and Wastewater (2005) 21st edition, Publication of the American Public Health Association (APHA), the

American Water Works Association (AWWA), and the Water Environment Federation (WEF); edited by Andrew D. Eaton, Mary Ann H. Franson.

Mapping of Program Outcomes with Course

Outcomes Class: S.Y B.Sc. (Sem IV)

Course: Air and Water Microbiology

Subject: Microbiology

Course Code: MIB-254-VSC

Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2		1									1
CO2							2						
CO3						2		2					2
CO4		2	2		3								2
CO5	3			2	2	2		1		3	2	1	
CO6		2					2		2				
CO7	3		2			2				3	2	2	3

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

Justification for the mapping

PO1: Disciplinary Knowledge

The majority of course outcomes enrich disciplinary knowledge by extensively examining microorganisms within air and water ecosystems. This study encompasses their diversity, roles, and ecological impact, offering insights into specialized microbiological principles and methodologies specific to these environments. This contributes significantly to an in-depth understanding of microbial life within the context of environmental sciences.

PO2: Critical Thinking and Problem Solving

CO3, CO4, CO5, CO6, and CO7 foster critical thinking and problem-solving skills by tasking students with analyzing intricate microbial interactions in environmental systems and evaluating their implications for human health and ecosystems.

PO3: Social Competence

CO6 and CO7 promote social competence by encouraging collaborative fieldwork and interdisciplinary research projects aimed at addressing environmental concerns related to microbial communities.

PO4: Research-related Skills and Scientific Temper

CO5 and CO7 instill research-related skills by exposing students to various sampling, isolation, and analysis techniques used in studying microorganisms within these ecosystems, preparing them for scientific research endeavors.

PO5: Trans-disciplinary Knowledge

CO1, CO2, CO3, and CO7 foster transdisciplinary knowledge by integrating principles from microbiology, environmental science, chemistry, and engineering to tackle complex environmental challenges.

PO6: Personal and Professional Competence

CO4, CO5, and CO7 enhance skills in environmental monitoring and water treatment careers, fostering a sense of responsibility for environmental stewardship and professional development across scientific and environmental fields.

PO7: Effective Citizenship and Ethics

CO1 and CO5 promote effective citizenship and ethics by emphasizing responsible environmental stewardship and equipping students with the knowledge and values necessary to make informed decisions regarding environmental conservation and sustainable water use, contributing to community and ecosystem well-being.

PO8: Environment and Sustainability

CO1, CO3, CO4, and CO7 address environmental and sustainability concerns by exploring the essential role of microorganisms in maintaining ecosystem balance and investigating the impact of human activities on air and water quality. This equips students with the knowledge and tools to develop sustainable solutions for environmental challenges.

PO9: Self-directed and Lifelong Learning

CO3, CO5, and CO7 promote self-directed and lifelong learning by encouraging students to explore cutting-edge research, adapt to evolving environmental challenges, and remain updated with advancements in microbiological techniques and technology.

PO10: Digital Literacy

CO5 and CO7 engage students in data analysis, monitoring techniques, and report generation using digital tools. They also encourage the use of software for microbiological data interpretation, promoting digital fluency.

PO11: Leadership and Management Skills

CO5 and CO7 involve organizing field sampling, lab work, and team-based monitoring activities, requiring students to demonstrate initiative, coordination, and time management skills.

PO12: Entrepreneurship and Innovation

CO5 and CO7 foster applied skills in microbial monitoring and environmental technology, enabling students to consider innovative water and air sanitation systems, thus encouraging entrepreneurial thinking.

PO13: Global and Local Awareness

CO1, CO3, CO4, and CO7 directly relate to global issues such as climate change, pandemics, air/water pollution, and public health, encouraging awareness of environmental microbiology in both global and Indian contexts.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc. Microbiology
Programme code:	: USMI
Class	: S.Y B.Sc.
Semester	: IV
Course Type	: Minor (Theory)
Course Code	: MIB-256- MN
Course Title	: Water & waste water treatment
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

1. Understand the different types of water, including surface, ground, stored, distilled, mineralized, and de-mineralized water, and their characteristics.
2. Identify various contaminants found in water and their sources.
3. Comprehend the bacteriological standards of water quality as per Maharashtra Pollution Control Board (MPCB) and Central Pollution Control Board (CPCB) guidelines.
4. Learn the main functions of MPCB and CPCB in maintaining water quality standards for best-designated usages.
5. Explore the different methods of water purification, including physical, chemical, and biological techniques.
6. Gain knowledge of waterborne infections such as diarrhea, dysentery, typhoid, and cholera, and their impact on public health.
7. Recognize indicators of fecal pollution, including *Escherichia coli*, *Bifidobacterium*, *Streptococcus faecalis*, *Clostridium perfringens*.

Course Outcomes:

CO1: Demonstrate an understanding of various types of water and their significance in environmental and public health contexts.

CO2: Identify and categorize contaminants in water, and understand their sources and effects on health.

CO3: Apply knowledge of water quality standards as per MPCB and CPCB guidelines in assessing water safety.

CO4: Evaluate the functions of pollution control boards in maintaining water quality and ensuring public health.

CO5: Assess the effectiveness of different water purification methods and their applications in various settings.

CO6: Identify and explain common waterborne infections, understanding their transmission, symptoms, and prevention methods.

CO7: Detect and interpret indicators of fecal pollution in water, utilizing them for water quality assessment.

Credit		Topic & Learning Points	Teaching Hours
I	Unit 1	Introduction to Water Microbiology	15
		Definition and importance of water microbiology.	1
		Types of Water : Surface water, Ground water, Mineralized water, Demineralize water, Distilled water	2
		Contaminants found in Ground water and Stored water	1
		Types of microorganisms found in water (bacteria, fungi, protozoa, algae).	2
		Water borne Infections: Diarrhea - <i>Entamoeba</i> Dysentery- <i>Shigella</i> Typhoid Fever - <i>Salmonella typhi</i> Cholera - <i>Vibrio cholerae</i>	3
		Physico-chemical analysis of water : Physical parameters: Temperature, Color, Turbidity, Total Solids, Total Suspended Solids Chemical parameters: pH, Hardness, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD)	4
		Water purification: Physical and Chemical methods: Sedimentation, Filtration, distillation, chlorination, coagulation, flocculation	2
II	Unit 1	Bacteriological analysis of water for potability	9

		Bacteriological standards of Water Quality : i. Maharashtra pollution control board (MPCB), Main Functions of MPCB. ii. Central pollution control board (CPCB), Main functions of CPCB iii. Bureau of Indian standards (BIS) iv. World health Organization (WHO)	3
		Bacteriological tests of potability of water : a) Presumptive coliform count b) Confirmed test c) Completed test d) Eijkman test Membrane filter technique	4
		Indicators of faecal pollution : i. <i>Escherichia coli</i> ii. <i>Bifidobacterium</i> iii. <i>Streptococcus faecalis</i> iv. <i>Clostridium perfringens</i>	2
	Unit 2	Waste Water treatment & Management:	6
		a. Methods of effluent treatment – Primary, secondary, tertiary treatment	4
		b. Recycling of waste water and sludge	2

References:

- 1) Daniel Lim., Microbiology, 2nd Edition; McGraw-Hill Publication
- 2) Tortora G.J., Funke B.R., Case C.L. (2006) Microbiology: An Introduction. 8th Edition.
- 3) Pelzar M. J., Chan E. C. S., Krieg N. R. (1986) Microbiology. 5th Edition, McGraw-Hill Publication
- 4) Hans G. Schlegel (1993) General Microbiology, 8th Edition, Cambridge University Press

5) Martin Frobisher (1937) Fundamentals of Microbiology, 8th Edition, Saunders, Michigan University press

6) Standard Methods for the Examination of Water and Wastewater (2005) 21st edition, Publication of the American Public Health Association

Mapping of course outcomes and programme outcomes:

Class: S.Y. B.Sc. (Sem IV)

Subject: Microbiology

Course: Water & waste water treatment

Course code: MIB- 256-MN

Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2		1					1	1	2		2
CO2							2		1	2		2	3
CO3						2		2					
CO4		2	2		3							2	
CO5				2	2	3					2		
CO6	2	2					2	2	2	2	1		
CO7	3		2			3				3	2	2	3

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

Justification for the mapping

PO1: Knowledge of basic and applied sciences

This knowledge serves as the foundation for advanced studies and practical applications in environmental and public health fields & shows a strong correlation with the following COs. CO3 and C07 refers to Application of water quality standards as per MPCB and CPCB guidelines and Assessment of water purification methods.

PO2: Problem analysis and solving skills

Moderate to strong relations with various COs due to the practical and analytical nature of the course. CO1, CO4 and CO6 relates with understanding of various types of water and their environmental significance, Evaluation of pollution control board functions in public health and Identification of waterborne infections and understanding their impact.

PO3: Design/development of solutions

Students learn to apply microbiological principles to create effective and sustainable solutions for real-world water-related problems. CO4 and CO7 involves evaluation of pollution control board functions in public health. Detection and interpretation of fecal pollution indicators

PO4: Conduct investigations of complex problems

CO1, CO3 and CO5 foster understanding of various types of water and their environmental significance. Assessment of water purification methods and apply knowledge of water quality standards as per MPCB and CPCB guidelines.

PO5: Ethics and Social Responsibility

CO3, CO4, CO6 directly involves learning the functions of MPCB and CPCB, and standards for water safety, students appreciate the ethical responsibility of scientists in environmental protection and public health. They understand the moral implications of pollution control and reporting accuracy.

PO6: Understanding of professional and ethical responsibilities

Students learn about the ethical responsibilities in monitoring and reporting water quality, ensuring that public health is not compromised by negligence or mismanagement. CO3, CO5 and CO7 describes application of water quality standards as per MPCB and CPCB guidelines. Assessment of water purification methods and detection and interpretation of fecal pollution indicators.

PO7: Environment and sustainability awareness

The course emphasizes the importance of sustainable water management practices, understanding the ecological impacts of water pollutants, and the significance of recycling and treating wastewater. CO2: Identification and categorization of water contaminants, CO6: Identification of waterborne infections and understanding their impact and CO8: Conducting bacteriological tests for water potability.

PO8: Ability to work in multidisciplinary teams

Water microbiology often intersects with fields such as environmental science, public health, and engineering. CO3 address application of water quality standards as per MPCB and CPCB guidelines. CO5 involves assessment of water purification methods.

PO9: Communication skills

The course fosters the development of strong written and oral communication skills. CO6 foster identification of waterborne infections and understanding their impact.

PO10 – Problem Analysis

In CO1, CO2, CO3, CO5, CO7 students identify water quality issues, analyze contamination data, and interpret microbial counts to assess potability. They gain the ability to diagnose **problems** and **propose corrective actions** for improving water safety

PO11 – Application of Knowledge

CO1–CO7 students apply microbiological knowledge to evaluate, purify, and manage water quality. This demonstrates the practical relevance of theory to public health, environmental management, and sanitation practices.

PO12 – Life-long Learning

CO5, CO6, CO7 relates by connecting microbiological theory with current water management challenges, students develop an appreciation for continuous learning, staying updated with new purification technologies and global water safety standards

PO13 – Health and Hygiene Awareness

CO1, CO2, CO4, CO6, CO7 involves the study of waterborne diseases (typhoid, cholera, dysentery, etc.) and indicators of faecal pollution directly contributes to awareness of public health, hygiene, and preventive sanitation measures — key components of community well-being.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc. Microbiology
Programme code:	: USMI
Class	: S.Y B.Sc.
Semester	: IV
Course Type	: Minor (Practical)
Course Code	: MIB-257- MN
Course Title	: Water Microbiology
No. of Credits	: 02
No. of Teaching Hours	: 60

Course Objectives :

1. Familiarize students with various microbiological methods used to analyze water samples for microbial contamination and quality indicators.
2. To develop practical skills in detecting waterborne pathogens using traditional methods such as the Multiple-Tube Fermentation method, EMB agar, and membrane filtration.
3. Evaluate the physical and chemical properties of water, including testing for Total Solids (TS), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS).
4. To gain proficiency in measuring the levels of dissolved oxygen (DO) in water and determining microbial contamination through the total viable bacterial count.
5. Assess the presence of antibiotic-resistant waterborne bacteria and understand the implications for public health.
6. To study and apply disinfection methods (UV light and chlorine) to reduce microbial load in water
7. Identify & understand the importance of fungal contamination detection and its effects on water quality and public health.

Course Outcomes:

CO1: Understand and identify microbial water quality indicators such as coliforms and other pathogens.

CO2: Gain proficiency in applying and interpreting results from the Multiple-Tube Fermentation method for detecting coliforms.

CO3: Perform laboratory tests to measure physical and chemical parameters of water, including solids content.

CO4: Analyze microbial contamination levels by assessing the total viable bacterial count and dissolved oxygen levels in water

CO5: Conduct antibiotic sensitivity testing on waterborne pathogens and assess their resistance profiles.

CO6: Apply UV light and chlorine disinfection techniques to assess their effectiveness in controlling microbial growth in water.

CO7: Detect and identify fungal contamination in water samples and understand the impact of such contamination on water quality.

Expt No.	Practicals	Teaching hour
1.	Microscopic Examination of Water Samples	4
2.	Determination of coliforms Using Multiple-Tube Fermentation Method	4
3.	Confirmed test	4
4.	Completed test	4
5.	IMViC test	4
6.	Membrane Filtration Technique	4
7-8	Testing for Total Solids, Total Suspended Solids & Total Dissolved Solids (TDS) in Water	8
9.	Determination of Dissolved Oxygen (DO)	4
10.	Determination of total viable bacterial count in water	4
11.	Determination of hardness of water	4
12.	Demonstration of water Purification methods	4
13.	Effect of UV Light on bacteria.	4
14.	Determination of Effect of Chlorine on Bacterial Growth in Water	4
15.	Visit to Water Purification Plant	4
Total		60

References:

- 1) Daniel Lim., Microbiology, 2nd Edition; McGraw-Hill Publication
- 2) Tortora G.J., Funke B.R., Case C.L. (2006) Microbiology: An Introduction. 8th Edition.
- 3) Pelzar M. J., Chan E. C. S., Krieg N. R.(1986) Microbiology. 5th Edition, McGraw-Hill Publication
- 4) Hans G. Schlegel (1993) General Microbiology, 8th Edition, Cambridge University Press
- 5) Martin Frobisher (1937) Fundamentals of Microbiology, 8th Edition, Saunders, Michigan University press
- 6) Standard Methods for the Examination of Water and Wastewater (2005) 21st edition, Publication of the American Public Health Association

Mapping of Program Outcomes with Course Outcomes

Class: S.Y.B.Sc (Sem IV)

Subject: Microbiology

Course: Water Microbiology Practicals

Course Code: MIB-257-MN

Course outcomes (COs)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PO13
CO1	3	2		1						2	1		2
CO2							2				1		2
CO3						2		2				2	
CO4		2	2		3					3			
CO5	3			2	2	2		1				2	
CO6		2					2		2				
CO7	3		2			2				2	3		3

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

Justification for the mapping

PO1: Disciplinary Knowledge

The majority of course outcomes enrich disciplinary knowledge by extensively examining microorganisms within air and water ecosystems. This study encompasses

their diversity, roles, and ecological impact, offering insights into specialized microbiological principles and methodologies specific to these environments.

PO2: Critical Thinking and Problem Solving

CO3, CO4, CO5, CO6, and CO7 foster critical thinking and problem-solving skills by tasking students with analyzing intricate microbial interactions in environmental systems and evaluating their implications for human health and ecosystems.

PO3: Social Competence

CO6 and CO7 promote social competence by encouraging collaborative fieldwork and interdisciplinary research projects aimed at addressing environmental concerns related to microbial communities.

PO4: Research-related Skills and Scientific Temper

CO5 and CO7 instill research-related skills by exposing students to various sampling, isolation, and analysis techniques used in studying microorganisms within these ecosystems, preparing them for scientific research endeavors.

PO5: Trans-disciplinary Knowledge

CO1, CO2, CO3, and CO7 foster transdisciplinary knowledge by integrating principles from microbiology, environmental science, chemistry, and engineering to tackle complex environmental challenges.

PO6: Personal and Professional Competence

CO4, CO5, and CO7 enhance skills in environmental monitoring and water treatment careers, fostering a sense of responsibility for environmental stewardship and professional development across scientific and environmental fields.

PO7: Effective Citizenship and Ethics

CO1 and CO5 promote effective citizenship and ethics by emphasizing responsible environmental stewardship and equipping students with the knowledge and values necessary to make informed decisions regarding environmental conservation and sustainable water use, contributing to community and ecosystem well-being.

PO8: Environment and Sustainability

CO1, CO3, CO4, and CO7 address environmental and sustainability concerns by exploring the essential role of microorganisms in maintaining ecosystem balance and investigating the impact of human activities on air and water quality. This equips students with the knowledge and tools to develop sustainable solutions for environmental challenges.

PO9: Self-directed and Lifelong Learning

CO3, CO5, and CO7 promote self-directed and lifelong learning by encouraging students to explore cutting-edge research, adapt to evolving environmental challenges, and remain updated with advancements in microbiological techniques and technology

PO10: Communication Skills

Course outcomes such as CO2, CO3, CO4, and CO5 strengthen communication skills by requiring students to record, interpret, and present experimental results clearly through lab reports, data sheets, and viva presentations. Students also learn to discuss microbial findings and water quality results using scientific terminology.

PO11: Project Management and Leadership Skills

CO4, CO5, CO6, and CO7 contribute to developing leadership and project management abilities as students plan, execute, and interpret experiments involving microbial load assessment, disinfection studies, and water quality improvement.

PO12: Entrepreneurship and Innovation

CO5 and CO6 directly promote innovation and entrepreneurship by introducing students to applied microbiological testing techniques that have real-world industrial relevance — such as antibiotic resistance profiling and evaluating disinfection technologies.

PO13: Digital Literacy and Global Competence

CO3, CO4, and CO5 foster digital literacy by involving the use of instruments, digital data recording, online research, and reference to international standards such as WHO and BIS for water quality.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc. Microbiology
Program Code	: USMI
Class	: S.Y.B.Sc.
Semester	: IV
Course Type	: Open Elective (Practical)
Course Name	: Practical Course based on Human Health and Microbes
Course Code	: MIB-258-OE
No. of Teaching Hours	: 60
No. of Credits	: 02

	Course Objective:
1.	Students will be able to understand the basics of microbiology, including the types of microorganisms, their characteristics and their roles in various environments.
2.	Students will able to learn about the factors affecting microbial growth and the methods used to culture and maintain microorganisms in the laboratory.
3.	Students will able to understand different methods of sterilization and disinfection used to eliminate or reduce microbial contamination
4.	Student will able to understand aseptic techniques to handle microorganisms without contaminating the samples or the environment.
5.	Student will able to learn microscopic examination use a microscope to observe and identify different types of microorganisms.
6.	To understand the methods used to isolate and identify specific microorganisms from a mixed culture.
7.	Student will able to understand safety procedure to prevent accidents and contamination.

	Course Outcome:
CO1.	Students will understand the basic principles of microbiology.
CO2.	Students will Acquire skills in aseptic techniques for handling microorganisms.
CO3.	Students will be able to perform basic microbiological tests such as staining, culture, and identification of microorganisms.
CO4.	Students able to learn about laboratory techniques and understanding the clinical significance of the results.
CO5.	Students will be able to develop skills in microscopy for the observation of microorganisms.
CO6.	Students will understand the importance of microbiology in various industries and fields.
CO7.	Students will gain practical experience in microbiological techniques through laboratory exercises and experiments.

No of Experiments	Topic	Teaching Hours
1.	Safety in microbiological laboratory.	4
2.	Sterilization, disinfection techniques	4
3.	Effect of soap and disinfectant on skin microflora	4
4.	Microscopic observation of bacteria by Negative staining from clinical samples	4
5.	Study of colony characteristics of some common bacteria: <i>Bacillus/ E. coli/ Staphylococcus/ Pseudomonas</i> , etc.	4
6.	Detection of Bacterial oxidase	4
7.	Detection of Bacterial catalase	4
8.	Preparation of bacterial smear and capsule staining	4
9.	Maintenance of stock cultures: slants/ stabs/ glycerol stock cultures	4
10.	Demonstration of permanent slide- Malarial parasites	4
11.	Observation of fungal pathogen by wet mount	4
12.	Observation of yeast pathogen by wet mount	4
13.	Blood grouping by slide agglutination test	4
14-15	Estimation of Hemoglobin by acid hematin & Cyanmethemoglobin method	8

References:

1. Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology:An Introduction. 8th Edition. Pearson Education Inc
2. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Hill Publishing Co.
3. Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987)General Microbiology, 5th Edition. Macmillan Press Ltd.
4. Prescott, Lancing. M., John, P. Harley and Donald, A. Klein (2006) Microbiology, 6th Edition, McGraw Hill Higher Education
5. Michael J Pelczar, JR. E.C.S. Chan, Noel R. Krieg. (1993) Microbiology, 5th Edition, Tata MacGraw Hill Press.
6. McDonnell G. E. (2020). Antisepsis, Disinfection, and Sterilization: Types, Action, and Resistance. United States: Wiley.
7. Murphy D. B. and Davidson M. W. (2012). Fundamentals of Light Microscopy and Electronic Imaging. Germany: Wiley.

Mapping of course outcomes and programme outcomes:

Class: S.Y.B.Sc. (Sem IV)**Subject:** Microbiology**Course:** Practical Course based on Human Health and Microbes (Practical)**Course code:** MIB-258-OE

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)												
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	2												
CO2	2	2		2				2					
CO3	3						3						
CO4											2	2	
CO5								2				2	
CO6			2										
CO7		3			3		2		2				

Justification for the mapping**PO1: Comprehensive Knowledge and Understanding:**

CO1: Basic microbiological techniques practical serve as the foundation for understanding fundamental principles and concepts in microbiology. Students learn essential techniques such as aseptic technique, microbial culturing, staining, and microscopy, which form the basis of more advanced microbiological studies.

CO2: Practical laboratory exercises provide students with hands-on experience and reinforce theoretical concepts learned in lectures or textbooks.

CO3: Comprehensive knowledge and understanding enable students to apply theoretical principles to real-world laboratory scenarios, enhancing comprehension and retention of material.

PO2: Practical, Professional, and Procedural Knowledge:

CO2: Basic microbiological techniques practical provide students with opportunities to develop practical skills essential for working in laboratory settings.

CO7: Through hands-on experience, students gain proficiency in techniques such as aseptic handling, microbial culturing, staining, and microscopy, enhancing their practical competency and confidence.

PO3: Entrepreneurial Mindset and Knowledge:

CO6: Basic microbiological techniques practical provide opportunities for students to apply innovative thinking and creativity in solving scientific problems and developing novel solutions.

PO4: Specialized Skills and Competencies:

CO2: Basic microbiological techniques practical require specialized skills such as aseptic technique, microbial culturing, staining, microscopy, and biochemical assays. Students develop hands-on proficiency in performing these techniques accurately, efficiently, and safely, laying the foundation for more advanced microbiological studies.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning:

CO7: Microbiological experiments often require careful planning and design to address specific research questions or hypotheses. Application problem-solving skills enable students to select appropriate methodologies, design experimental protocols, and identify variables that may impact experimental outcomes, fostering critical thinking and analytical reasoning in experimental planning.

PO7: Research-related Skills:

CO3: Basic microbiological techniques practical involve designing experiments to test hypotheses or address research questions.

CO4: Research-related skills enable students to develop experimental designs that are scientifically rigorous, feasible, and appropriate for the objectives of the study.

PO8: Learning How to Learn Skills:

CO2: Basic microbiological techniques practical provide an opportunity for students to learn how to adapt to new environments, procedures, and challenges.

CO5: Learning how to learn skills enable students to quickly acquire new knowledge, techniques, and protocols, allowing them to adapt and thrive in diverse laboratory settings.

PO9: Digital and Technological Skills:

CO7: Microbiological experiments generate large volumes of data that require organization, analysis, and storage. Digital skills enable students to use spreadsheet software, databases, and laboratory information management systems (LIMS) to manage experimental data efficiently, ensuring accuracy, accessibility, and reproducibility.

PO11: Value Inculcation and Environmental Awareness:

CO4: Microbiological research involves ethical considerations regarding the responsible use of microorganisms, adherence to biosafety protocols, and respect for research participants and the environment.

PO12: Autonomy, Responsibility, and Accountability:

CO4: Autonomy allows students to make independent decisions during experiments, such as selecting appropriate procedures and interpreting results.

CO5: Accountability in this setting means students are accountable for accurately documenting their procedures, results, and any deviations, as well as taking responsibility for the overall success and integrity of the experiment.

CBCS Syllabus as per NEP 2020 for S. Y. B.Sc. Microbiology (2024 Pattern) (w.e.f. November 2025)	
Name of the Programme	: B.Sc. Microbiology
Program Code	: USMI
Class	: S.Y.B.Sc.
Semester	: IV
Course Type	: Skill Enhancement Course (Practical)
Course Name	: Dairy Microbiology
Course Code	: MIB-259-SEC
No. of Credits	: 02
No. of Teaching Hours	: 60

Course Objectives:

1. To understand microbiological techniques used for analyzing the microbial quality of milk and dairy products.
2. To learn standard enumeration methods such as the Standard Plate Count (SPC) and Direct Microscopic Count (DMC) for bacterial assessment in milk.
3. To gain practical knowledge of microbiological quality control tests such as the Methylene Blue Reduction Test (MBRT), Mastitis Test, and Somatic Cell Count.
4. To analyze the effectiveness of pasteurization using the Phosphatase Test.
5. To develop proficiency in milk component analysis, including fat estimation and adulteration detection.
6. To learn the principles and methods of milk fermentation for curd production and isolation of lactic acid bacteria.
7. To acquire industrial exposure by visiting a dairy plant and preparing a detailed report on milk processing techniques.

Course Outcomes:

- CO. 1 Students will be able to perform microbiological tests on milk samples to assess their microbial load and hygiene quality.
- CO. 2 Students will be able to apply bacterial enumeration techniques such as SPC and DMC to determine the bacterial content in milk.
- CO. 3 Students will be able to conduct microbiological quality control tests like MBRT, Mastitis Test, and Somatic Cell Count to evaluate milk quality.
- CO. 4 Students will be able to evaluate pasteurization efficiency using the Phosphatase Test and interpret its significance.
- CO. 5 Students will be able to detect adulterants in milk, such as water, starch, detergent, urea, and formalin, using standard detection methods.
- CO. 6 Students will be able to prepare fermented milk products like curd and successfully isolate and identify lactic acid bacteria from dairy samples.
- CO. 7 Students will be able to demonstrate an understanding of industrial dairy microbiology by compiling a visit report on dairy plant operations.

Sr.No.	Name of Experiments	Teaching Hours
1-2	Microbiological analysis of milk: Enumeration of bacteria - Standard Plate Count Direct Microscopic Count	08
3-6	Microbiological quality control tests for milk: Dye reduction test (MBRT/Resazurin) Mastitis test Somatic cell count Phosphatase test	16
7	Milk Fat Estimation Test	04
8	Preparation of fermented milk product-Paneer	04
9	Isolation & Identification of Lactic acid bacteria from curd	04
10-12	Milk Adulteration Tests For: a. Water b. Starch c. Detergent d. Urea e. Formalin f. Ammonium sulfate	12
13	Microbiological quality of indigenous dairy productus: Shrikhand	04
14	Microbiological quality of indigenous dairy productus: Curd	04
15	Visit to a dairy & preparation of visit report	04

References:

1. Richard K. Robinson (2012) – *Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products*, 3rd Edition, Wiley-Blackwell.
2. James G. Fox, Lynn C. Anderson (2015) – *Laboratory Animal Medicine*, 3rd Edition, Academic Press.
3. B.H. Webb, A.H. Johnson (1965) – *Fundamentals of Dairy Chemistry*, Springer.
4. Varnam, A. H., & Sutherland, J. P. (1994) – *Milk and Milk Products: Technology, Chemistry and Microbiology*, Springer.
5. Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006) – *Dairy Science and Technology*, 2nd Edition, CRC Press.
6. Tamime, A. Y. (2009). *Probiotic Dairy Products*. Wiley-Blackwell.
7. IDF (International Dairy Federation) Reports on Microbial Quality of Dairy Products.
8. Patel, R. S. (2019). *Microbiological aspects of dairy processing* – Journal of Dairy Research.
9. Indian Standards (IS 1479, IS 5402) for microbiological examination of milk.

10. Food Safety and Standards Authority of India (FSSAI) – *Manual of Methods of Analysis of Foods: Milk and Milk Products*.
11. Codex Alimentarius – Guidelines on Milk Hygiene and Safety.
12. BIS (Bureau of Indian Standards) – Standards for Milk Quality Testing.

Mapping of Program Outcomes with Course Outcomes

Class: S.Y.BSc (Sem IV)

Subject: Microbiology

Course: Dairy Microbiology

Course code: MIB-259-SEC

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Course Outcomes	(Programme Outcomes)												
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13
CO 1	3	3		3		2		2		2			
CO 2	3	3		3		2		2					
CO 3	3	3		3		2			1		2		1
CO 4	3			3									
CO 5	3	3						3				3	
CO 6	3				3			3					
CO 7			3		3		3		3				

Justification for Mapping

PO1: Assessing milk safety & quality

PO1 is strongly related to outcomes that involve direct testing and analysis of milk quality, such as milk quality tests, detection of adulterants, and microbial contamination detection. These outcomes are crucial for ensuring the safety and quality of milk, aligning directly with PO1. Outcomes like milk fat estimation and health risk analysis also support PO1 by providing key quality indicators. The field visit provides indirect insights into milk safety practices, offering moderate relevance to PO1.

PO2: Practical, professional, and procedural

PO2 is strongly related to all course outcomes, as each involves hands-on application of techniques and professional procedures. From milk quality testing and adulterant detection to the preparation of dairy products and microbial contamination detection, all outcomes require practical skills and adherence to professional standards. The field visit also fosters practical engagement with real-world dairy operations, emphasizing procedural knowledge. Overall, PO2 is integral to each outcome, ensuring that students develop the necessary practical expertise.

PO3: Entrepreneurial Mindset and Knowledge

PO3 is moderately related to most outcomes, as it encourages innovative thinking in areas such as adulterant detection and microbial contamination, where new methods could be developed. The preparation of dairy products like curd and paneer has a stronger link, as entrepreneurial skills are essential for product innovation and market development. Outcomes focused on practical applications, like milk quality tests and health risk analysis, benefit from an entrepreneurial approach to problem-solving and process improvement. However, the field visit has a weaker connection, as it mainly involves observation rather than entrepreneurial thinking.

PO4: Specialized Skills and competencies

PO4 is strongly related to all outcomes, as each involves the application of specialized knowledge and technical skills. From conducting milk quality tests and detecting adulterants to analyzing milk fat and microbial contamination, these outcomes require specific competencies in dairy science and laboratory techniques. The preparation of fermented dairy products also demands specialized skills in dairy processing. While the field visit involves more observational learning, it still provides insights into industry practices that contribute to the development of specialized competencies.

PO5: Capacity for Application, Problem-Solving

PO5 is strongly related to outcomes like milk quality tests, adulterant detection, and microbial contamination detection, where problem-solving is essential to interpret results and ensure safety. Estimating milk fat and somatic cell count also requires applying knowledge to solve specific quality-related problems. The preparation of dairy products and analyzing milk quality involves troubleshooting techniques and adapting processes. The field visit offers some problem-solving opportunities, but its focus is more on observation than hands-on problem resolution.

PO6: Communication Skill and Collaboration

PO6 is strongly related to outcomes like field visits and report preparation, where clear communication and collaboration are essential for sharing findings and working with others. Milk quality tests, adulterant detection, and microbial contamination detection also require effective communication of results, though collaboration is less emphasized in these technical processes. The preparation of fermented dairy products may involve teamwork and communication within production settings. Analyzing milk quality and health risks also requires the clear communication of findings, especially in reporting and advising on safety concerns.

PO7: Research-related Skills

PO7 is moderately related to outcomes like milk quality tests, adulterant detection, and microbial contamination detection, where research skills can help refine techniques or explore new methods. Estimating milk fat and somatic cell count and analyzing milk quality also benefit from research skills in improving accuracy or developing better procedures. The preparation of dairy products may involve research to innovate or optimize processes. The field visit has a weaker connection to PO7, as it focuses more on observation and practical learning rather than research activities.

PO8: Learning How to Learn Skills

PO8 is moderately related to all outcomes, as each requires ongoing learning and adaptation to improve techniques and methodologies. Outcomes like milk quality testing, adulterant detection, and microbial contamination detection encourage continuous learning to enhance accuracy and efficiency. The preparation of dairy products and health risk analysis also benefit from developing the ability to learn and apply new knowledge. While the field visit provides learning opportunities, it is less focused on formal learning and more about real-world exposure.

PO9: Digital and Technological Skill Use of certain technologies and digital tools for these tests

PO9 is moderately related to outcomes that involve laboratory testing and analysis, such as milk quality tests and microbial contamination detection, where digital tools and technologies are often used for precise measurements and data analysis. Estimating milk fat and somatic cell count also requires the use of digital tools for accurate readings. The preparation of dairy products and field visits are less reliant on digital technology, though digital tools may assist in documentation or analysis. Overall, PO9 is more strongly connected to technical outcomes that involve digital tools for testing and analysis.

PO10 : Multicultural Competence, Inclusive Spirit, and Empathy

PO10 is moderately related to all outcomes, as each involves understanding diverse practices and perspectives in the dairy industry. The field visit provides the most direct exposure to different cultural and operational practices, fostering empathy and inclusivity. Outcomes like detecting adulterants and analyzing milk quality may involve understanding local variations in practices or consumer needs. While less directly related, each outcome benefits from an inclusive approach to ensuring safe and quality milk for diverse populations.

PO11: Value Inculcation and Environmental Awareness

PO11 is moderately related to outcomes such as microbial contamination detection and milk quality tests, where environmental considerations play a role in ensuring safe, sustainable practices. The preparation of dairy products also links to this PO, as environmental awareness is essential in optimizing resource usage and minimizing waste. Detecting adulterants and analyzing milk quality may involve understanding the broader implications of food safety on public health and the environment. The field visit offers insights into sustainable dairy farming practices, enhancing environmental awareness.

PO12: Autonomy, Responsibility, and Accountability

PO12 is strongly related to all outcomes, as each involves taking responsibility for accurate testing, analysis, and decision-making in dairy practices. Conducting milk quality tests, detecting adulterants, and microbial contamination detection all require students to demonstrate accountability in ensuring safety and quality. Estimating milk fat and somatic cell count, as well as preparing dairy products, necessitates taking ownership of processes and outcomes. The field visit emphasizes responsibility in observing and understanding real-world dairy operations, promoting autonomous learning and professional accountability.

PO13: Community Engagement and Service

PO13 is moderately related to outcomes like the field visit, where students engage with local dairy farms and communities to understand industry practices. Analyzing milk quality and detecting adulterants aligns with serving the community by ensuring safe and healthy dairy products. The preparation of fermented dairy products also connects to community service by contributing to local food systems. While other outcomes focus more on technical skills, all contribute to the broader goal of ensuring quality and safety for the community.