Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science andCommerce, Baramati

(Autonomous)

Four Year B. Sc. Degree Program in Microbiology

(Faculty of Science and Technology)

Choice-Based Credit System Syllabus

(2023 Pattern) (As Per NEP 2020)

S. Y. B. Sc. Microbiology

Semester IV

To be implemented from Academic Year 2023-2024

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

Preamble

Anekant Education Society's Tuljaram Chaturchand College has decided to change 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 F. Y. B. Sc. Microbiology Semester - I as per Choice Based Credit System (CBCS) by following the guidelines of NEP 2020, NCrF, 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)

PSO1 **Comprehensive Knowledge and Understanding**: Graduates will possess a profound understanding of their field of study, including foundational theories, principles, methodologies, and key concepts, within a broader multidisciplinary context.

PSO2 **Practical, Professional, and Procedural Knowledge**: Graduates will acquire practical skills and expertise essential for professional tasks within their field. This includes knowledge of industry standards, best practices, regulations, and ethical considerations, with the ability to apply this knowledge effectively in real-world scenarios.

PSO3 **Entrepreneurial Mindset and Knowledge**: Graduates will cultivate an entrepreneurial mindset, identifying opportunities, fostering innovation, and understanding business principles, market dynamics, and risk management strategies.

PSO4 **Specialized Skills and Competencies**: Graduates will demonstrate proficiency in technical skills, analytical abilities, problem-solving, effective communication, and leadership, relevant to their field of study. They will also adapt and innovate in response to changing circumstances.

PSO5 **Capacity for Application, Problem-Solving, and Analytical Reasoning**: Graduates will possess the capacity to apply learned concepts in practical settings, solve complex problems, and analyze data effectively. This requires critical thinking, creativity, adaptability, and a readiness to learn and take calculated risks.

PSO6 **Communication Skills and Collaboration**: Graduates will effectively communicate complex information, both orally and in writing, using appropriate media and language. They will also collaborate effectively in diverse teams, demonstrating leadership qualities and facilitating cooperative efforts toward common goals.

PSO7 **Research-related Skills**: Graduates will demonstrate observational and inquiry skills, formulate research questions, and utilize appropriate methodologies for data collection and analysis. They will also adhere to research ethics and effectively report research findings.

PSO8 **Learning How to Learn Skills**: Graduates will acquire new knowledge and skills through self-directed learning, adapt to changing demands, and set and achieve goals independently.

PSO9 **Digital and Technological Skills**: Graduates will demonstrate proficiency in using ICT, accessing information sources, and analyzing data using appropriate software.

PSO10 **Multicultural Competence, Inclusive Spirit, and Empathy**: Graduates will engage effectively in multicultural settings, respecting diverse perspectives, leading diverse teams, and demonstrating empathy and understanding of others' perspectives and emotions.

PSO11 **Value Inculcation and Environmental Awareness**: Graduates will embrace ethical and moral values, practice responsible citizenship, recognize and address ethical issues, and take appropriate actions to promote sustainability and environmental conservation.

PSO12 **Autonomy, Responsibility, and Accountability**: Graduates will apply knowledge and skills independently, manage projects effectively, and demonstrate responsibility and accountability in work and learning contexts.

PSO13 **Community Engagement and Service**: Graduates will actively participate in community-engaged services and activities, promoting societal well-being.

Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science andCommerce, Baramati
(Autonomous)

Board of Studies (BoS) in Microbiology

From 2022-23 to 2024-25

Sr. No.	Name	Designation
1.	Prof. Dr. S. T. Pawar	Chairman
2.	Prof. Dr. M. H. Gajbhiye	Member
3.	Prof. Dr. Y. R. Mulay	Member
4.	Mr. D. V. Doshi	Member
5.	Mrs. K. R. Jagtap	Member
6	Ms P. C. Bhosale	Member
7	Prof. Dr. Snehal Kulkarni	Expert from SPPU, Pune
8.	Prof. Dr. T. A. Kadam	Expert from other University
9.	Prof. Dr. A. V. Pethkar	Expert from other University
10.	Mr. Pradip Lonkar	Industry Expert
11	Ms Chaitrali Pathak	Meritorious Alumni
12.	Ms Sonali Sawant	Student Representative

Anekant Education Society's

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

Course Structure for S.Y.B.Sc. 2023-2024 (Microbiology) (2023 Pattern)

Sem	Course Type	Course Code	Course Name	Theory/ Practical	Credits	Marks(I + E)
III	Major Mandatory	MIB-201-MJM	Bacterial Systematics	Theory	02	20+30
	Major Mandatory	MIB-202-MJM	Soil Microbiology	Theory	02	20+30
	Major Mandatory	MIB-203-MJM	Air Microbiology	Theory	02	20+30
	Major Mandatory	MIB-204- MJM	Practicals on Bacterial Systematics, Soil Microbiology, Air Microbiology	Practical	02	25+25
	Minor	MIB-211- MN	Basic Microbiology	Theory	02	20+30
	Minor	MIB-212- MN	Basic Microbiological Techniques	Practical	02	25+25
	Open Elective (OE)	MIB-216-OE	Scope & History of Microbiology	Theory	02	20+30
	Vocational Skill Course (VSC)	MIB-221-VSC	Dairy Microbiology	Theory	02	20+30
	Ability Enhancement Course (AEC)	MAR-231-AEC HIN-231-AEC SAN-231-AEC	□□□□□ □□□□□□ □ □□□□ □□□□□□ □□□□□ □□□□ □□□□ □□□□□□□□ □□□□□□ □□□□□□□□	Theory	02	20+30
	Field Project (FP)	MIB-235-FP	Field Project	Practical	02	25+25
	Co-curricular Course (CC)	YOG/PES/CUL/NSS /NCC-239-CC	NSS/NCC/Yoga/Cultural activities/Sports	Theory	02	20+30
	Generic IKS Course	GEN-245-IKS	Indian Knowledge System (Generic)	Theory	02	20+30
	Total Credits Semester-III				24	
IV	Major Mandatory	MIB-251-MJM	Bacterial Physiology	Theory	02	20+30
	Major Mandatory	MIB-252-MJM	Introduction to Industrial Microbiology	Theory	02	20+30
	Major Mandatory	MIB-253-MJM	Water Microbiology	Theory	02	20+30
	Major Mandatory	MIB-254-MJM	Practical Based on Bacterial Physiology, Industrial Microbiology, Water Microbiology	Practical	02	25+25
	Minor	MIB-261-MN	Essentials of Microbiology	Theory	02	20+30
	Minor	MIB-262-MN	Microbiology laboratory essentials	Practical	02	25+25
	Open Elective (OE)	MIB-266-OE	Practicals on Scope & History of Microbiology	Practical	02	25+25
	Skill Enhancement Course (SEC)	MIB-276-SEC	Practicals on Dairy Microbiology	Practical	02	25+25
	Ability Enhancement Course (AEC)	MAR-281-AEC HIN-281-AEC SAN-281-AEC	□□□□ □□□□□□□□ □ □□□□□□□ □□□□□□□ □□□□□ □□□□ □□□□□□□□ □□□□ □□□□□ □□□□□□ □□□□□□□□	Theory	02	20+30
	Community Engagement Project (CEP)	MIB-285-CEP	Community Engagement Project	Practical	02	25+25
	Co-curricular Course (CC)	YOG/ PES/ CUL/NSS/ NCC-289-CC	NSS/NCC/Yoga/Cultural activities/Sports	Theory	02	20+30
	Total Credits Semester-IV				22	
	Cumulative Credits Semester III + Semester IV				46	

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- MJM**
Course Title	**: Bacterial Physiology**
No. of Credits	**: 02**
No. of Teaching Hours	**: 30**

Course Objectives:

1. Introduce students to fundamental concepts of metabolism, including catabolism, anabolism, respiration, and fermentation.
2. Explore the metabolic diversity and nutritional types of organisms, focusing on autotrophs, phototrophs, and chemotrophs.
3. Provide a comprehensive understanding of enzymes, including their nature, structure, and role as biocatalysts in metabolic reactions.
4. Examine different models of enzyme catalysis, including the lock-and-key, induced fit, and transition state models.
5. Investigate the factors affecting enzyme activity, such as pH, temperature, substrate concentration, and enzyme concentration.
6. Understand the pathways involved in sugar degradation and ATP production, including EMP, ED, TCA cycle, and the electron transport chain.
7. Explore the mechanisms of oxidative phosphorylation, substrate-level phosphorylation, and fermentation in energy production.

Course Outcomes:

CO1	Students will be able to define and differentiate between metabolism, catabolism, anabolism, respiration, and fermentation.
CO2	Students will be able to classify organisms based on their metabolic diversity and nutritional types.
CO3	Students will understand the nature and properties of enzymes, including the roles of coenzymes, apoenzymes, prosthetic groups, and cofactors.
CO4	Students will be able to explain and compare the different models of enzyme catalysis.
CO5	Students will demonstrate an understanding of the factors that influence enzyme activity, such as pH, temperature, and substrate concentration.
CO6	Students will be able to describe and compare various sugar degradation pathways and their roles in cellular metabolism.
CO7	Students will understand the processes of ATP production through oxidative phosphorylation, substrate-level phosphorylation, and fermentation

Credit		Learning & Teaching Points	Teaching Hours
I	**Unit 1**	**Introduction to Metabolism** 1. Definitions of Metabolism, catabolism, anabolism, respiration and Fermentation. 2. Concept of aerobic respiration, anaerobic respiration and fermentation 3. Metabolic diversity and Nutritional types Autotroph/Phototroph, heterotroph, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph	**6** 2 2 2
	Unit 2	**Biocatalysts** 1. Introduction to Enzymes: Nature and properties of enzymes, coenzymes, apoenzyme, prosthetic groups and cofactors, ribozyme, Enzyme unit. 2. Structure of active site; common amino acids at active site. 3. Models for catalysis - a) Lock and key b) Induced fit c) Transition state 4. Effect of pH & temperature, substrate concentration & enzyme concentration, activators and inhibitors on enzyme activity 5. Nomenclature & classification as per IUB (up to class level).	**9** 2 1 3 2 1
II	**Unit 1**	**Metabolic Pathways** 1. Sugar degradation pathways a) EMP Pathway b) ED Pathway c) Glyoxylate Pathway d) Pentose phosphate pathway 2. TCA cycle 3. ATP: The major energy currency of cells 4. Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, 5. Oxidative phosphorylation and Substrate level phosphorylation 6. Fermentation : Homofermentative pathway Heterofermentative pathway	**15** 5 3 1 2 2 2
Total			**30**

Mapping of course outcomes and programme outcomes:

Class : SYBSc (Sem IV) **Subject : Microbiology**

Course : Bacterial Physiology **Course code : MIB-251-MJM**

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	3	2	1	1	2	1	2	3	1	1	1	1	1
CO2	2	2	2	1	2	1	2	2	1	2	1	1	2
CO3	3	2	1	1	2	1	2	2	1	1	1	1	2
CO4	2	2	1	2	2	1	2	2	1	1	1	1	1
CO5	2	3	1	3	3	1	2	3	2	1	2	2	2
CO6	2	3	1	2	3	2	2	2	2	1	3	2	1
CO7	3	2	2	2	3	1	2	2	1	1	2	3	2

Justification for the mapping

PO1 Comprehensive Knowledge and Understanding
CO1 and CO3 align strongly with PO1 as they provide a deep understanding of fundamental metabolic processes and enzyme functions, which are essential for any microbiologist's foundational knowledge.

PO2 Practical, Professional, and Procedural Knowledge
CO5 and CO6 contribute to PO2 by requiring students to understand and apply knowledge about enzyme activity and metabolic pathways in practical settings. This knowledge is crucial for conducting laboratory experiments and interpreting results professionally.

PO3 Entrepreneurial Mindset and Knowledge
CO2 has a moderate link to PO3, as classifying organisms based on metabolic diversity can inspire entrepreneurial ventures in biotechnology and environmental microbiology, such as identifying organisms with unique metabolic capabilities for industrial use.

PO4 Specialized Skills and Competencies
CO4 and CO7 are closely aligned with PO4, as they develop specialized competencies in enzyme catalysis models and ATP production mechanisms. These skills are essential for advanced studies and careers in biochemistry and microbiology.

PO5 Capacity for Application, Problem-Solving, and Analytical Reasoning
CO6 and CO7 support PO5 by requiring students to apply analytical reasoning to understand and compare different metabolic pathways and energy production processes. This ability is crucial for solving complex biological problems.

PO6 Communication Skills and Collaboration
CO5 connects to PO6, as it requires students to effectively communicate their understanding of factors influencing enzyme activity, which is important when collaborating on experimental designs or sharing results with peers.

PO7 Research-related Skills
CO3 and CO5 strongly align with PO7, as they involve conducting research to understand enzyme

properties and activity under various conditions. These research skills are fundamental for pursuing advanced studies or careers in microbiology and biochemistry.

PO8 Learning How to Learn Skills

CO1 and CO4 contribute to PO8 by fostering a learning mindset, encouraging students to explore and differentiate between various metabolic processes and enzyme catalysis models, which are crucial for continuous learning in scientific fields.

PO9 Digital and Technological Skills

CO5 has a potential link to PO9, as the study of enzyme activity might involve using digital tools and technology for data collection and analysis, which is becoming increasingly important in modern scientific research.

PO10 Multicultural Competence, Inclusive Spirit, and Empathy

CO2 offers a minimal but relevant connection to PO10, as understanding metabolic diversity can foster an appreciation for biological diversity across different organisms, potentially leading to a broader understanding and empathy towards global biodiversity.

PO11 Value Inculcation and Environmental Awareness

CO6 and CO7 contribute to PO11 by enhancing students' awareness of the importance of metabolic pathways and energy production in ecological contexts, thereby instilling a sense of responsibility towards environmental sustainability.

PO12 Autonomy, Responsibility, and Accountability

CO1, CO5, and CO7 align with PO12 by encouraging students to take responsibility for their learning and understanding of metabolic processes, enzyme activity, and energy production, which is vital for conducting independent and accountable research.

PO13 Community Engagement and Service

CO2 and CO7 connect to PO13 by highlighting the role of microbial diversity and energy production in broader community and environmental contexts, potentially guiding students towards community-focused applications of microbiology

CBCS Syllabus As Per NEP 2020 (2023 Pattern) for S.Y.B.Sc.Microbiology

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- MJM**
Course Title	**:Introduction to Industrial Microbiology**
No. of Credits	**: 02**
No. of Teaching Hours	**: 30**

Course Objectives

1. To understand the desirable characteristics of industrially important microbial strains and the principles of primary and secondary screening methods.
2. To learn the preparation and maintenance of stock cultures and inoculum for industrial fermentation processes.
3. To explore the design and operation of a typical continuously stirred tank reactor (CSTR) and its components in industrial fermentation.
4. To comprehend the process control and monitoring of key fermentation parameters, including temperature, pH, aeration, agitation, and foam control.
5. To differentiate between various fermentation types such as batch, continuous, and dual fermentations and their industrial applications.
6. To develop knowledge of media formulation for industrial fermentations, including the selection of carbon and nitrogen sources, vitamins, minerals, and other critical components.
7. To examine the importance of sterilization in fermentation, including methods for sterilizing air, media, equipment, and handling waste byproducts.

Course Outcomes

CO1: Demonstrate knowledge of industrial microbial strains and their desirable characteristics for large-scale production.
CO2: Apply screening methods to select and optimize microbial strains for industrial applications.
CO3: Operate and maintain a fermenter by understanding its components and their roles in the fermentation process.
CO4: Monitor and control critical fermentation parameters to optimize production efficiency and product quality.
CO5: Distinguish between different fermentation processes and apply the appropriate method based on industrial requirements.
CO6: Formulate and optimize media compositions for various fermentation processes, addressing the specific needs of industrial production.
CO7: Implement sterilization techniques to prevent contamination and ensure the safety and efficiency of industrial fermentation operations.

Credit		Learning & Teaching Points	Teaching Hours
I	**Unit 1**	**Basics of Industrial Microbiology**	**15**
		a. Industrially important strains	
		i. Desirable characteristics of industrial strain	1
		ii. Principle and methods of primary and secondary screening	3
		iii. Stock culture & Inoculum preparation	2
		b. Design of fermenter (Typical CSTR Continuously stirred tank reactor); Different parts and their operation	3
		c. Process control and Monitoring of different fermentation parameters (Temperature, pH, aeration, agitation, foam)	4
		d. Types of fermentations: Batch, continuous, dual fermentations	2
II	**Unit 1**	**Media for industrial fermentations**	**15**
		Formulation of media for Industrial fermentation (carbon source, nitrogen source, amino acids, vitamins, minerals, water, buffers, antifoam agents, precursors, inhibitors and inducers)	8
	Unit 2	**Sterilization in fermentation industry** Importance of sterilization in fermentation industry and consequences of contamination	**1**
		Sterilization of air, Filter sterilization of fermentation media, Sterilization of fermenter and feed/additives, liquid wastes	3
	Unit 3	**Treatment of effluent obtained from fermentation industry** Disposal Treatment processes Byproducts	3
Total			**30**

References :

1. Casida LE. (1984) Industrial Microbiology. Wiley Easterbs, New Delhi
2. Ingraham J. L. and Ingraham C.A. (2004) Introduction to Microbiology. 3nd Edition. Thomson Brooks / Cole.
3. Modi H. A., (2008) Fermentation Technology – Volumes I and II, Pointer Publishers, Jaipur, India
4. Patel A.H. (1985) Industrial Microbiology, Macmillan India Ltd.
5. Peppler H.L. (1979) Microbial Technology, Vol I and II, Academic Press.
6. Prescott S.C. and Dunn C.G. (1983) Industrial Microbiology.
7. Reed G. AVI tech books. 16.Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Publishing Co.
8. Martin A. Introduction to Soil Microbiology (1961) John Wiley& Sons, New York and London publication
9. Subba Rao N. S. (1977) Soil Microbiology, 4th Ed., Oxford & IBH Publishing Co. Pvt. Ltd.
10. Dubey R.C., and Maheswari, D.K. Textbook of Microbiology, S. Chand & Co.
11. Mexander M. (1977) Introduction to soil microbiology, John Wilery NY.
12. Dube H.C. and Bilgrami. K.S.(1976) Text book of modern pathology. Vikas publishing house. New Delhi.
13. Rangaswami G. (1979) Recent advances in biological nitrogen fixation. Oxford and IBH. New Delhi.
14. Stanbury P. F. and Whittaker A. (1984) Principles of Fermentation technology. Pergamon Press

Mapping of Program Outcomes with Course Outcomes

Class : S.Y.B.Sc (Sem III) **Subject: Microbiology**

Course : Introduction to Industrial Microbiology **Course Code : MIB-252-MJM**

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

Course Outcomes	Programme Outcomes (POs)												
	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	2			2	2	3						
CO 2	3		2										1
CO 3	3	3	2										
CO 4		2							2			2	
CO 5	2		2	3						1			1
CO 6	3					2	3						
CO 7		3	2	3									

Justification for the mapping

PO1 Comprehensive Knowledge and Understanding :
Strong connection as these CO1, CO4, CO5, CO7: directly involve understanding microorganisms, fermenter design, process control, media formulation, and metabolite production, which require comprehensive knowledge.

PO2 **Practical, Professional, and Procedural Knowledge**
Relates to CO2, CO3, CO4, CO5, CO7:
Strong connection because these COs involve practical applications like screening techniques, inoculum development, and operating fermenters.

PO3 **Entrepreneurial Mindset and Knowledge :**
Direct relation as COs involves understanding metabolite production, which is relevant for entrepreneurial ventures in biotechnology. Moderate connection to other COs as they contribute to entrepreneurial skills, such as strain selection and process optimization.

PO4 **Specialized Skills and Competencies:**
CO2, CO3, CO4, CO5, CO7 shows Strong connection as these COs involve developing specialized skills in fermentation and microbiological processes.

PO5 **Capacity for Application, Problem-Solving, and Analytical Reasoning**:
CO1, CO3, CO4, CO5, CO6, CO7. Strong connection because problem-solving and analytical reasoning are key to designing and optimizing fermentation processes.

PO6 **Communication Skills and Collaboration to COs:**
Moderate connection as communication and collaboration are important in practical and theoretical group work and lab settings

PO7 **Research-related Skills:**
CO1, CO4, CO5 shows Strong connection as these COs involve research elements like strain screening, process monitoring, and metabolite production.

PO8 **Learning How to Learn Skills:**
Strong connection to as CO7 involves continuously improving knowledge about industrial microbiology, including evolving techniques in metabolite production. Moderate connection to other COs where continuous learning is required for practical applications

PO9 **Digital and Technological Skills** :
CO4, CO5 Strong connection as these COs require the use of digital tools and technology in process monitoring and control.

PO10 **Multicultural Competence, Inclusive Spirit, and Empathy** :
Weak connection as the focus of these COs is on technical knowledge, with minimal emphasis on multicultural competence

PO11 **Value Inculcation and Environmental Awareness** :
Strong connection as CO8 involves contamination management, which is critical for environmental and ethical considerations . Moderate connection to other COs related to environmental implications in industrial processes

PO12 **Autonomy, Responsibility, and Accountability :**
CO2, CO3, CO4, CO5, CO6, CO7 Strong connection as these COs require students to manage processes, take responsibility, and ensure quality control.

PO13 **Community Engagement and Service** :
Weak connection as these COs are focused on technical skills with limited direct relation to community engagement. This mapping ensures that the course outcomes align effectively with the broader program outcomes, supporting comprehensive student development across various competencies.

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-253- MJM**
Course Title	**: Water Microbiology**
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, *E.coli* infection, and cholera, and their impact on public health.
7. Recognize indicators of fecal pollution, including *Escherichia coli*, *Bifidobacterium*, *Streptococcus faecalis*, *Clostridium perfringens*, and emerging indicators like *Campylobacter* and *Pseudomonas*.

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		Learning & Teaching Points	Teaching Hours
I	**Unit 1**	**INTRODUCTION TO WATER MICROBIOLOGY**	**15**
		1. Types of water: Surface, ground, stored, distilled, mineralized and de-mineralized water.	**2**
		2 .Contaminants found in the surface and stored water.	**1**
		3. Bacteriological standards of Water Quality: i. Maharashtra pollution control board (MPCB) Main Functions of MPCB Water quality standards for best designated usages ii. Central pollution control board, (CPCB) Main Functions of CPCB Designated Best Use Water Quality Criteria	**2**
		3. Water purification methods: 1. Physical methods 2. Chemical methods	**3**
		4. Water borne Infections: Diarrhea - *Entamoeba, Giardia* Dysentery- *Shigella, E. coli* Typhoid Fever - *Salmonella typhi* Cholera - *Vibrio cholerae* Hepatitis- Hepatitis A/C	**3**
		5. Indicators of faecal pollution: i. *Escherichia coli* ii. *Bifidobacterium* iii. *Streptococcus faecalis* iv. *Clostridium perfringens* v. New indicators: *Campylobacter* and *Pseudomonas*	**4**
II	**Unit 1**	**BACTERIOLOGICAL ANALYSIS OF POTABLE WATER**	**15**
		i. Bacteriological standards of potable water: Bureau of Indian standards (BIS) World health Organization (WHO)	**2**
		ii. Presumptive coliform count	**1**

		iii. Confirmed test	**1**
		iv. Completed test	**1**
		v. Membrane filtration technique	**1**
	Unit 2	**WASTE WATER ANALYSIS**	
		a. Analysis of waste water i. Physico-chemical parameters: pH, temperature, total solids, suspended solids, Chemical Oxygen Demand (COD) ii. Biological parameters: Biological Oxygen Demand (BOD) iii. Industrial water pollutants, their ecological effects and health hazards (Biomagnifications and eutrophication)	**3**
	Unit 3	**WASTE WATER MANAGEMENT**	
		a. Methods of effluent treatment – Primary, secondary, tertiary treatment methods	**4**
		b. Recycling of waste water and sludge	**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

CBCS Syllabus As Per NEP 2020 (2023 Pattern) for S.Y.B.Sc.Microbiology

Mapping of course outcomes and programme outcomes:

Class : SYBSc (Sem IV) **Subject : Microbiology**

Course : Major Mandotary **Course code : MIB-253 MJM**

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

	Programme Outcomes (POs)												
Course outcomes (COs)	**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**
CO1	3	2		1						2			
CO2							2						3
CO3						2		2			2		
CO4		2	2		3								3
CO5	3			2	2	2		1					
CO6		2					2		2				
CO7	3		2			2					3		3

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: Application of water quality standards as per MPCB and CPCB guidelines.

CO5: Assessment of water purification methods.

CO7**:** Detection and interpretation of fecal pollution indicators.

PO2: **Problem analysis and solving skills**

Moderate to strong relations with various COs due to the practical and analytical nature of the course.

CO1: Understanding of various types of water and their environmental significance

CO4: Evaluation of pollution control board functions in public health.

CO6**:** 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: Evaluation of pollution control board functions in public health.

CO7**:** Detection and interpretation of fecal pollution indicators

PO4: Conduct investigations of complex problems

CO1: Understanding of various types of water and their environmental significance..

CO5: Assessment of water purification methods.

CO3**:** Apply knowledge of water quality standards as per MPCB and CPCB guidelines.

PO5: **Modern tool usage**

CO4: Evaluation of pollution control board functions in public health.

CO5: Assessment of water purification methods.

CO9: Performing comprehensive sewage and wastewater analysis and treatment.

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: Application of water quality standards as per MPCB and CPCB guidelines.

CO5: Assessment of water purification methods.

CO7: 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.

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: Application of water quality standards as per MPCB and CPCB guidelines.

CO5: Assessment of water purification methods.

PO9: Communication skills

The course fosters the development of strong written and oral communication skills.

CO6: Identification of waterborne infections and understanding their impact.

PO10: **Lifelong learning**

The field of water microbiology is dynamic, with new challenges and technologies constantly emerging.

CO1**:** Understanding of various types of water and their environmental significance.

PO11: **Project management and finance**

Managing water treatment projects, whether in a research or industrial context, requires project management skills, including budgeting and resource allocation.

CO3: Application of water quality standards as per MPCB and CPCB guidelines

CO7: Detection and interpretation of fecal pollution indicators

PO12: Knowledge of contemporary issues the course addresses contemporary issues such as waterborne diseases, pollution control, and emerging contaminants, which are critical for ensuring safe water supplies.

PO13: **Leadership skills and team management**

As future leaders in the field, students need to develop leadership and team management skills to guide multidisciplinary teams in addressing water microbiology challenges, implementing solutions, and ensuring that water quality standards are met.

CO2: Identification and categorization of water contaminants.

CO4: Evaluation of pollution control board functions in public health.
CO7:Detection and interpretation of fecal pollution indicator

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-254- MJM**
Course Title	**: Practical Based on Bacterial Physiology, Introduction to Industrial Microbiology, Water Microbiology**
No. of Credits	**: 02**
No. of Practicals	**: 15**

Course Objectives:

1. To impart knowledge on the growth dynamics of bacteria using methods such as turbidometry and standard plate count.
2. To develop skills in calculating bacterial generation time and specific growth rates from experimental data.
3. To explore the influence of pH, temperature, carbon, and nitrogen sources on bacterial growth.
4. To familiarize students with the concepts of thermal death time and decimal reduction time for bacterial populations.
5. To introduce students to primary screening methods for industrially important microorganisms such as organic acid and antibiotic producers.
6. To provide hands-on experience in microbial fermentations for the production and estimation of enzymes, amino acids, organic acids, and alcohol.
7. To educate students on bacteriological tests for water potability and the determination of wastewater parameters such as BOD.

Course Outcomes:

CO1 Students will be able to effectively plot and analyze the growth curve of E. coli using both turbidometric and standard plate count methods.

CO2 Students will be proficient in calculating and interpreting generation time and specific growth rates from experimental growth data.

CO3 Students will understand the effects of environmental factors such as pH, temperature, and nutrient sources on bacterial growth.

CO4 Students will be able to demonstrate and explain the concepts of thermal death time and decimal reduction time in bacterial populations.

CO5 Students will acquire the ability to perform primary screening for industrially relevant microorganisms, including those producing organic acids and antibiotics.

CO6 Students will develop the skills to carry out microbial fermentations and estimate the production of key metabolites such as enzymes, amino acids, organic acids, and alcohol.

CO7 Students will gain competency in performing bacteriological tests for water potability, including MPN, membrane filtration, and BOD determination for wastewater.

Pr. No	Topic & Learning Points	Teaching Hours
	Bacterial physiology	
1	Study and plot the growth curve of *E.coli* by turbidometric method	4
2	Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.	4
3-5	Study of factors affecting growth of *E.coli*:	
	a. Effect of Agitation	4
	b. Effect of carbon sources	4
	c. Effect of nitrogen sources	4
	Introduction to Industrial Microbiology	
6	Primary screening of industrially important organisms: a. Organic acid producing microorganisms b. Antibiotic producing microorganisms (Crowded plate technique)	4
7	Demonstration of different parts of fermenter	4
8	Production of bacterial amylase at laboratory scale and its qualitative estimation	4
9	Production of ethanol at laboratory scale and its qualitative estimation	4
	Water Microbiology	
10	Determination of Total solid, Total dissolved solids and total suspended solid in wastewater sample	4
11-12	Bacteriological tests to check the potability of water a. MPN b.Confirmed and completed test	8
13	Membrane filtration technique (Demonstration)	4
14	Determination of BOD of wastewater sample.	4
15	Visits to Water purification plant/ Sewage treatment plant/Effluent treatment plant/ Fermentation industry	4
Total		**60**

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1. Bergey's Manual of Systematic Bacteriology by John G. Holt et al.
2. Practical Handbook of Microbiology, Third Edition by Emanuel Goldman and Lorrence H. Green
3. Microbial Physiology, Fourth Edition by Moat, John, Foster, and Michael P.
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6. 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
7. Tortora G.J., Funke B.R., Case C.L. (2006) Microbiology: An Introduction.

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10. 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 course outcomes and programme outcomes:

Class : SYBSc (Sem IV) **Subject : Microbiology**

Course : Practicals on MIB-251-MJM, MIB-252-MJM, MIB-253-MJM

Course code : MIB-254-MJM

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	3	3	1	2	3	1	2	2	2	1	1	1	1
CO2	3	3	1	2	3	1	2	2	2	1	1	1	1
CO3	3	3	1	3	3	1	2	2	2	1	1	1	1
CO4	3	3	1	2	3	1	2	2	2	1	1	1	1
CO5	3	3	1	3	3	2	2	2	2	1	1	2	2
CO6	3	3	2	3	3	2	2	2	2	1	1	2	2
CO7	3	3	1	3	3	2	2	2	2	1	3	2	2

Justification for the mapping

PO1 Comprehensive Knowledge and Understanding
Cos like CO1, CO2, CO3, CO4, CO5, CO6, and CO7 strongly align with PO1 as they require a deep understanding of microbial physiology, industrial microbiology, and environmental microbiology. This comprehensive knowledge is foundational for effectively executing and understanding the course objectives.

PO2 Practical, Professional, and Procedural Knowledge
Cos such as CO1, CO2, CO3, CO4, CO5, CO6, and CO7 directly contribute to PO2 by requiring hands-on skills in experimental procedures and microbiological techniques. Practical knowledge gained through these Cos is crucial for professional competency in microbiology.

PO3 Entrepreneurial Mindset and Knowledge
.CO6 has a moderate connection to PO3, as understanding microbial fermentation can inspire entrepreneurial initiatives in biotechnology. The entrepreneurial aspect is

less prominent in other Cos, though applicable in certain industrial contexts.

PO4 Specialized Skills and Competencies

Cos like CO3, CO5, CO6, and CO7 are strongly aligned with PO4, as they involve specialized microbiological skills in areas such as environmental microbiology, industrial screening, and fermentation processes. Mastery of these specialized competencies is key to success in advanced microbiological applications.

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

Cos such as CO1, CO2, CO3, CO4, CO5, CO6, and CO7 align closely with PO5, as they require strong analytical reasoning and problem-solving skills in various microbiological contexts. Application of these skills is critical for interpreting data and solving microbiological problems.

PO6 Communication Skills and Collaboration

Cos like CO5, CO6, and CO7 moderately contribute to PO6, where effective communication and collaboration are essential, particularly in industrial and environmental microbiology settings. While not the primary focus, these Cos encourage clear communication of scientific findings.

PO7 Research-related Skills

Cos such as CO1, CO2, CO3, CO4, CO5, CO6, and CO7 support PO7 by involving research skills in data collection, analysis, and interpretation across different microbiological experiments. These Cos are fundamental for developing a research-oriented approach in microbiology.

PO8 Learning How to Learn Skills

Cos like CO1, CO2, CO3, CO4, CO5, CO6, and CO7 align well with PO8, encouraging independent learning and the application of new concepts in microbiology. These Cos foster a continuous learning mindset, essential for adapting to new challenges.

PO9 Digital and Technological Skills

Cos such as CO1, CO2, CO3, CO4, CO5, CO6, and CO7 contribute to PO9 by potentially involving digital tools and technologies in microbiological analysis and experimentation. Developing technological skills through these Cos is important for modern microbiological practices.

PO10 Multicultural Competence, Inclusive Spirit, and Empathy

CO7 has a minimal but relevant connection to PO10, as water quality testing raises awareness of global health issues and fosters empathy. The other Cos have limited direct relevance to multicultural competence but contribute to broader scientific understanding.

PO11 Value Inculcation and Environmental Awareness

Cos like CO3 and CO7 are linked to PO11, as they promote environmental awareness through the study of microbial growth in different conditions and water quality testing. These Cos instill a sense of responsibility towards environmental and public health.

PO12 Autonomy, Responsibility, and Accountability

Cos such as CO1, CO5, CO6, and CO7 align with PO12 by encouraging students to take responsibility for their experiments and results. Autonomy and accountability are crucial for ensuring accurate and ethical scientific work.

PO13 Community Engagement and Service

Cos like CO5, CO6, and CO7 contribute to PO13 by linking microbiological practices to community service, such as through the production of industrially significant products and water quality testing. These Cos highlight the importance of microbiology in serving community needs.

Name of the Programme : B.Sc Microbiology
Programme Code : USMI
Class : S.Y.B.Sc.
Semester : IV
Course Type : Minor (Theory)
Course Code : MIB-261-MN
Course Title : Essentials of Microbiology
No. of Credits : 02
No. of Teaching Hours : 30

Course Objectives

1. Understanding Nutritional Requirements: To introduce students to the nutritional classification of microorganisms and the composition of various types of growth media.
2. Cultivation Techniques: To provide knowledge about the methods used for cultivating photosynthetic bacteria, chemoautotrophic bacteria, and extremophiles.
3. Isolation and Preservation Methods: To educate students on various techniques for isolating and preserving microorganisms, ensuring their long-term viability.
4. Bacterial Growth Phases: To explain the phases of the bacterial growth curve, including key concepts such as generation time, growth rate, and specific growth rate.
5. Enumeration of Bacteria: To familiarize students with different methods for enumerating bacterial populations, including microscopic counts, plate counts, biomass estimation, and turbidimetric methods.
6. Factors Affecting Bacterial Growth: To explore the influence of factors like pH, temperature, solute concentration, and heavy metals on bacterial growth.
7. Specialized Growth Conditions: To introduce students to specialized bacterial growth conditions such as diauxic growth, synchronous culture, and continuous cultivation using chemostats and turbidostats.

Course Outcomes :

CO1 Understanding Nutritional Classification: Students will be able to classify microorganisms based on their nutritional requirements and describe the components of various types of growth media.

CO2 Application of Cultivation Methods: Students will gain practical knowledge in cultivating different types of bacteria, including photosynthetic and chemoautotrophic bacteria, and extremophiles

CO3 Proficiency in Isolation and Preservation: Students will be proficient in using various isolation techniques (streak plate, spread plate, pour plate) and preservation methods (agar slant, soil & grain culture, saline suspension, freezing, lyophilization).

CO4 Comprehension of Growth Phases: Students will be able to explain the phases of the bacterial growth curve and calculate generation time, growth rate, and specific growth rate.

CO5 Skill in Bacterial Enumeration: Students will be skilled in enumerating bacterial populations using microscopic methods, plate counts, biomass estimation, and turbidimetric methods

CO6 Understanding Growth Factors: Students will understand how environmental factors like pH, temperature, solute concentration, and heavy metals affect bacterial growth and will be able to explain the concepts of diauxic growth and synchronous culture.

CO7 Mastery of Continuous Cultivation: Students will be able to describe and apply the

principles of continuous cultivation using chemostats and turbidostats.

Credit No	Topic	Lectures
I	**Cultivation of Microorganisms**	**15**
	Unit 1: Nutritional requirements: a) Nutritional classification of microorganisms b) Common ingredients of media c) Types of media	**5**
	Unit 2 : Isolation and Preservation a) Isolation techniques - i. Streak Plate Method ii. Spread Plate Method iii. Pour Plate Method	**6**
	b) Preservation techniques - i. Agar Slant Method ii. Soil & Grain Culture Method iii. Saline Suspension Method iv. Freezing Method v. Lyophilization	**4**
II	**Bacterial Growth**	**15**
	Unit 1 : Phases of bacterial Growth curve Definition of : i. Generation / Cycle ii. Generation time iii. Growth rate and iv. Specific growth rate	**2**
	Unit 2 : Methods for the Enumeration of Bacteria: a) Microscopic Methods i. Direct Microscopic Count ii. Counting cells by Neubauer's chamber	**2**
	b) Plate counts	**1**
	c) Turbidimetric methods	**1**
	Unit 3:	**2**
	a) Factors affecting bacterial growth: i. pH ii. Temperature iii. Salt Concentration	**3**
	iv. Heavy metals	**2**
	b) Diauxic growth, Synchronous growth	**2**

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, Mc Graw Hill Higher Education.
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6. Michael J Pelczar, JR. E.C.S.Chan, Noel R.Krieg. (1993) Microbiology, 5thEdition, Tata Mac Graw Hill Press.
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9. Mount,D.W.(2001) Bioinformatics: Sequence and Genome analysis. Cold Spring Harbor Laboratory Press, New York.

Mapping of course outcomes and programme outcomes:

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	3	2	1	3	2	1	2	2	1	1	1	2	1
CO2	3	3	1	3	3	1	2	2	1	1	1	2	1
CO3	3	3	1	3	3	1	2	2	1	1	1	2	1
CO4	3	2	1	3	3	1	2	2	1	1	1	2	1
CO5	3	3	1	3	3	1	2	2	1	1	1	2	1
CO6	3	3	1	3	3	1	2	2	1	1	1	2	1
CO7	3	3	1	3	3	1	2	2	1	1	1	2	1

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 Each CO directly contributes to building comprehensive knowledge in key areas such as microbial nutrition, cultivation techniques, bacterial growth phases, and enumeration, aligning strongly with PO1.

PO2: Practical, Professional, and Procedural:

CO1, CO4 These COs involve understanding concepts and performing calculations related to bacterial growth, which have moderate practical and procedural relevance.

CO2, CO3, CO5, CO6, CO7 These COs directly involve hands-on laboratory techniques and cultivation methods, strongly aligning with practical and procedural skills.

PO3: Entrepreneurial Mindset and Knowledge:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 While the COs provide essential knowledge, their

contribution to fostering an entrepreneurial mindset is limited.

PO4: Specialized Skills and Competencies:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 These COs equip students with specialized skills and competencies in microbial cultivation, isolation, and growth analysis, aligning strongly with PO4.

PO5: Capacity for Application, Problem-Solving:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 Each CO supports the application of knowledge to practical scenarios, enabling problem-solving in microbial cultivation and growth conditions.

PO6: Communication Skill and Collaboration:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 These COs focus more on technical skills and knowledge rather than communication and collaboration, though some collaboration is implied in lab settings.

PO7: Research-related Skills:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 Understanding the growth phases, enumeration techniques, and cultivation methods contributes to the development of research skills, particularly in experimental microbiology.

PO8: Learning How to Learn Skills:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 These COs foster an approach to learning that encourages ongoing inquiry and adaptation, especially in mastering new cultivation and enumeration techniques.

PO9: Digital and Technological Skills:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 The course does not heavily focus on digital or technological skills, although some COs might involve the use of technology in bacterial enumeration and data analysis.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 The COs do not directly address multicultural competence, inclusivity, or empathy, though these values may be indirectly supported in a collaborative learning environment.

PO11: Value Inculcation and Environmental Awareness:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 The focus is primarily on technical skills, with limited emphasis on value inculcation or environmental awareness, though these aspects can be indirectly fostered through responsible laboratory practices.

PO12: Autonomy, Responsibility, and Accountability:

CO1, CO2, CO3, CO4, CO5, CO6, CO7 These COs encourage students to take responsibility for their laboratory work and understanding of microbial growth, promoting autonomy and accountability in a scientific context.

PO13: Community Engagement and Service:

CO1, CO3, CO7 The direct impact on community engagement and service is limited, though some knowledge might be applied in community health and environmental microbiology contexts.

Name of the Programme : B.Sc Microbiology
Program Code : USMI
Class : S.Y.B.Sc
Semester : IV
Course Type : Minor Practicals
Course Title : Microbiology Laboratory Essentials
Course Code : MIB-262-MN
No. of Credits : 02
No. of Teaching Hours : 60

Course Objectives:

1. Understand and demonstrate the basic components, care, and maintenance of a microscope.
2. Perform the hanging drop method to assess bacterial motility.
3. Execute the swarming growth method to observe bacterial movement and growth patterns.
4. Employ spread plate and pour plate methods for the enumeration of bacteria from fermented food, soil, and water samples.
5. Observe and report the growth of bacterial cultures on nutrient and MacConkey's agar, focusing on colony and cultural characteristics.
6. Preserve microbial cultures using various techniques, including agar slants, saline suspensions, and lyophilization.
7. Assess the sterilization efficiency of an autoclave through practical tests.
8. Evaluate the efficacy of chemical disinfectants using the phenol coefficient and Rideal-Walker method.
9. Isolate and grow fungi from spoiled food or vegetables, and study their characteristics.

Course Outcomes:
CO1: Students will be able to properly set up, use, and maintain a microscope, understanding its components and care requirements.
CO2: Students will demonstrate the ability to use the hanging drop method to observe and analyze bacterial motility.
CO3: Students will execute the swarming growth method to study bacterial growth patterns and behavior.
CO4: Students will effectively use spread plate and pour plate methods to enumerate bacteria in various samples, interpreting the results accurately.
CO5. Students will observe and document bacterial growth and cultural characteristics on different media, such as nutrient and MacConkey's agar.
CO6: Students will successfully preserve microbial cultures using different techniques and explain the purpose of each method.
CO7: Students will evaluate and ensure the efficiency of autoclave sterilization through practical demonstrations.
CO8: Students will determine the effectiveness of chemical disinfectants and compare them using phenol coefficient and Rideal-Walker methods.
CO9 : Students will learn to Isolate and grow fungi from spoiled food or vegetables.

Pr. No.	Topics and learning points	Teaching Hours
1.	Basic components, Handling and Maintenance of Compound Microscope.	**4**
2-3.	Determination of motility of bacteria by Hanging drop method, Swarming growth method	**8**
4.	Enumeration of bacteria from fermented food/soil water by: a) Spread plate method b) Pour plate method.	**4**
5.	Observation of bacterial growth and reporting of colony characteristics: (Nutrient agar and MacConkey's agar).	**4**
6.	Preservation of cultures on agar slants.	**4**
7.	Sterilization Efficiency of Autoclave.	**4**
8.	Determination of Phenol Coefficient by Rideal Walker method (Demonstration).	**4**
9.	Isolation and growth of fungus from spoiled food/ Vegetables.	**4**
10.	Preparation of Winogradsky's column to study growth of microbial community.	**4**
11.	Effect of soap and disinfectant on skin microflora	**4**
12-14.	Effect of different parameters on bacterial growth: Temperature, pH, Salt Concentration	**12**
15.	Oligodynamic action of Heavy metals.	**4**

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Mapping of Program Outcomes with Course Outcomes

Class: S.Y.B.Sc (Sem IV) **Subject**: Microbiology

Course: Microbiology Laboratory Essential **Course Code:** MIB-261-MN

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	3	2											
CO2	3						2					1	2
CO3		2		2		2					1		
CO4			2			2		1					
CO5		2		2	2					1			
CO6	3								2				
CO7	3	2											

Justification of Mapping

PO1: Knowledge of basic and applied sciences
Mastery of microscopy, bacterial growth methods, and microbiological techniques requires a solid understanding of fundamental and applied microbiological sciences relates with CO1,CO2,CO6 .
Students will be able to properly set up, use, and maintain a microscope, understanding its components and care requirements.
Students will demonstrate the ability to use the hanging drop method to observe and analyze bacterial motility.

PO2 : Problem analysis and solving skills
Practical laboratory work often involves troubleshooting issues with techniques or interpreting unexpected results. Students will be able to properly set up, use, and maintain a microscope, understanding its components and care requirements. Students will execute the swarming growth method to study bacterial growth patterns and behavior show relation with CO1,CO3, CO5.

PO3: Design/development of solutions Moderate to weak relation, as the practicals focus more on applying existing methods rather than developing new solutions.
While the focus is on applying existing methods, understanding how to design or modify protocols for specific scenarios (e.g., developing new methods for preservation or treatment) is crucial

PO4 : Conduct investigations of complex problems
This PO highlights the importance of conducting thorough investigations and understanding

the intricacies of
Moderate to strong relation with CO4, CO7, and CO8, where complex investigations and assessments are involved.

PO5: Modern tool usage
Proficiency with modern laboratory tools, such as microscopes, autoclaves, and various plating techniques, is a core component of the practical syllabus.
Strong relation with CO1 and CO4, where using and maintaining modern laboratory tools and techniques are essential.

PO6 : Understanding of professional and ethical responsibilities
Moderate relation, as professional conduct is important but less emphasized in specific practical exercises.
Maintaining high standards in laboratory practices, including proper handling of samples and accurate reporting of results, is vital.

PO7: Environment and sustainability awareness: Weak to moderate relation, more relevant in context but not directly addressed by all practical exercises.

PO8 : Ability to work in multidisciplinary teams
Weak relation, as most practicals are individual exercises or small-group activities with limited multidisciplinary interaction.

PO9 : Communication skills:
Moderate to strong relation with CO4, CO5, CO7, CO8, and CO9, where effective documentation and communication of results are crucial.

PO10 :Lifelong learning
Weak to moderate relation, as practicals focus on current techniques rather than fostering ongoing learning habits.

PO11: Project management and finance):
Weak relation, as practicals do not typically involve project management aspects.
While not directly emphasized in the practical exercises, understanding project management and budgeting can be important in research or laboratory settings

PO12 : Knowledge of contemporary issues
Moderate relation with CO8, as evaluating chemical disinfectants relates to contemporary issues in public health and safety. Addressing contemporary issues such as the efficacy of disinfectants or environmental impacts of laboratory practices aligns with this PO.

PO13 : Leadership skills and team management
Weak relation, as practical exercises focus more on individual tasks rather than leadership or team management. Developing leadership and team management skills is essential for future roles in research or industry.

Name of the Programme	**: B.Sc Microbiology**
Programme Code	**: USMI**
Class	**: S.Y.B.Sc.**
Semester	**: IV**
Course Type	**: Open Elective Practical**
Course Code	**: MIB-266-OE**
Course Title	**: Practicals based on Scope and History of Microbiology**
No. of Credits	**: 02**
No. of Teaching Hours	**: 60**

Course Objectives:

1. To equip students with the skills required to handle, maintain, and care for microscopes, ensuring accurate and effective observation of microorganisms.
2. To provide students with the ability to observe and identify microorganisms from water samples using bright field microscopy, enhancing their understanding of microbial diversity.
3. To develop students' proficiency in various staining techniques, including monochrome and negative staining, for improved visualization and differentiation of microbial cells.
4. To familiarize students with the wet mounting technique for observing fungi, aiding in the identification and study of fungal structures.
5. To introduce students to historical microbiological experiments, such as Pasteur's swan necked flask and Redii's three jar experiment, demonstrating fundamental concepts in microbial contamination and spontaneous generation.
6. To train students in the preparation of fermented food products, such as Idli batter, and to understand the microbial processes involved in fermentation.
7. To enable students to isolate and identify amylase-producing bacteria and probiotic bacteria from dairy products, and to conduct antibiotic susceptibility testing, blood group determination, and other microbiological assays.

Course Outcomes:

CO1. Students will demonstrate proper handling, maintenance, and care of microscopes, ensuring precise and reliable observations in their microbiological studies.

CO2. Students will be able to accurately observe and identify microorganisms from water samples using bright field microscopy.

CO3. Students will proficiently apply monochrome and negative staining techniques to differentiate microbial cells, enhancing their microscopy skills.

CO4. Students will successfully perform wet mounting of fungi, enabling detailed observation and identification of fungal structures.

CO5. Students will gain an understanding of classical microbiological theories and experiments, such as those by Pasteur and Redii, applying these principles to modern microbiology.

CO6. Students will acquire practical skills in preparing fermented food products, understanding the microbial dynamics involved in the fermentation process.

CO7. Students will be proficient in isolating specific bacteria, conducting antibiotic susceptibility tests, determining human blood groups.

No. of Expt.	Topic	Teaching Hours
1	Handling, maintenance and care of microscope.	4
2	Observation of microorganism from water sample under bright field microscope.	4
3-4	Staining techniques. a. Monochrome staining. b. Negative staining.	8
5	Wet mounting of fungi.	4
6	Pasteur's swan necked flask experiment.	4
7	Redii's three jar experiment.	4
8	Preparation of fermented food product- Idli batter.	4
9	Preservation of milk by pasteurization/ boiling method.	4
10	Isolation of amylase producing bacteria.	4
11	Isolation of probiotic bacteria from dairy products. a. Curd/Buttermilk	4
12	Demonstration of antibiotic susceptibility test using Kirby Bauer method.	4
13	Determination of human blood group by slide agglutination test.	4
14	Joseph Lister's antiseptic technique.	4
15	Cultivation of Blue-Green Algae.	4

References:-

1. Microbiology: An Introduction by Tortora, Funke, and Case – Chapters on bacterial growth, and environmental effects.
2. Principles of Microbiology by Kathleen Park Talaro and Barry Chess – Historical experiments and microbial principles.
3. Microbiology: A Systems Approach by Marjorie Kelly Cowan – Detailed historical perspectives on abiogenesis and biogenesis.
4. Fundamentals of Microbiology by Pommerville – Microscopy techniques and microbial observation.
5. Environmental Microbiology by Ian L. Pepper, Charles P. Gerba, and Terry J. Gentry – Methods for isolating microorganisms from environmental samples.
6. Food Microbiology by Adams and Moss – Fermentation processes and microbial roles.
7. Probiotics and Prebiotics in Food, Nutrition, and Health by Preedy – Methods for isolating and identifying probiotics.
8. Antibiotics: Actions, Origins, Resistance by William M. MacDougall – Details on

susceptibility testing.

9. Medical Microbiology by Murray, Rosenthal, and Pfaller – Historical techniques and their impact.
10. Immunology: A Short Course by Richard Coico and Geoffrey Sunshine – Methods for immune assays.

Mapping of course outcomes and programme outcomes:

Class : S.Y.B.Sc (Sem IV) **Subject:** Microbiology

Course : Practical's based on Scope and History of Microbiology **Course Code :** MIB-266-OE

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

	Programme Outcomes (POs)												
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	3		3	2	2	2	2	1	1		2	
CO2	3	3		3	3	2	2	2	1	1		2	
CO3	3	3		3	3	2	2	2	1	1		2	
CO4	3	3		3	2	2	2	2	1	1		2	
CO5	3	2	2	3	2	2	2	2	1	1	2	2	
CO6	2	3	2	2	2	2	2	2	1	1	2	2	2
CO7	3	3	2	3	3	2	3	2	1	1	2	2	2

Justification for the mapping

PO1: Comprehensive Knowledge and Understanding:

CO1: Demonstrates comprehensive knowledge of microscope use, essential for accurate microbiological observation.

CO2: Requires understanding microbial morphology and water sampling techniques, reflecting comprehensive knowledge.

CO3: Involves understanding staining techniques to enhance microscopy, indicating deep knowledge of microbial visualization.

CO4: Necessitates understanding fungal biology and observation methods. CO5: Includes historical microbiological theories (Pasteur and Redii) which require understanding classical concepts.

CO6: Involves knowledge of fermentation processes, essential for understanding microbial fermentation in food production.

CO7: Covers various microbiological tests that require comprehensive knowledge of lab techniques and their applications.

PO2: Practical, professional and procedural:

CO1: Involves practical skills in handling and maintaining microscopes.

CO2: Requires practical skills in observing microorganisms under a microscope.

CO3: Requires proficiency in staining techniques, reflecting procedural skills.

CO4: Involves practical techniques for fungal observation.

CO5: Requires performing classical experiments, demonstrating procedural skills.
CO6: Involves hands-on preparation of fermented foods, highlighting practical skills.
CO7: Includes various microbiological tests and analyses, emphasizing practical and procedural skills.

PO3: Entrepreneurial Mindset and Knowledge:

CO5: Understanding historical experiments can influence innovation and entrepreneurship in microbiology.
CO6: Skills in fermentation can have entrepreneurial applications in food technology.
CO7: Skills in various microbiological tests can be applied in industry settings, linking to entrepreneurial activities.

PO4: Specialized Skills and competencies:

CO1: Requires specialized skills in microscope handling and maintenance.
CO2: Involves specialized skills in identifying microorganisms.
CO3: Requires specialized staining techniques for microbial visualization.
CO4: Involves specialized skills in wet mounting and fungal observation.
CO5: Understanding classical microbiological experiments reflects specialized knowledge.
CO6: Skills in preparing fermented foods involve specialized knowledge in microbiology.
CO7: Involves specialized skills in various microbiological techniques and analyses.

PO5: Capacity for Application, Problem-Solving:

CO1: Demonstrates problem-solving in microscope maintenance and care.
CO2: Applies techniques to solve problems related to microorganism observation.
CO3: Uses staining techniques to solve problems in microbial visualization.
CO4: Applies wet mounting techniques to solve problems in fungal identification.
CO5: Uses historical theories to solve problems related to microbial contamination.
CO6: Applies fermentation skills to solve problems in food production.
CO7: Uses various microbiological techniques to solve problems in microbial identification and testing.

PO6: Communication Skill and Collaboration:

CO1: Requires communication skills for effective microscope use and maintenance.
CO2: Involves communication for reporting microorganism observations.
CO3: Requires clear communication in applying and interpreting staining techniques.
CO4: Involves communication for fungal observation and identification.
CO5: Requires communication to explain historical experiments and their relevance.
CO6: Involves communication and collaboration in food preparation and fermentation.
CO7: Requires communication and collaboration for conducting and analyzing microbiological tests.

PO7: Research-related Skills:

CO1: Basic research skills in microscope handling and maintenance.
CO2: Research skills in identifying microorganisms from water samples.
CO3: Research skills in applying staining techniques for microbial analysis.
CO4: Research skills in fungal observation and identification.
CO5: Research skills in understanding classical microbiological experiments.
CO6: Research skills in understanding and applying fermentation processes.
CO7: Research skills in performing various microbiological tests and analyses.

PO8: Learning How to Learn Skills:

CO1: Involves learning to handle and maintain microscopes effectively.
CO2: Encourages learning to observe and identify microorganisms accurately.
CO3: Develops skills in learning and applying staining techniques.
CO4: Involves learning to perform wet mounting techniques for fungi.

CO5: Encourages learning from historical experiments and their applications.
CO6: Develops skills in learning fermentation processes and their practical applications.
CO7: Encourages learning and applying various microbiological techniques.

PO9: Digital and Technological Skills:

CO1: Minimal digital skills involved in microscope use.
CO2: Limited digital skills required for microorganism observation.
CO3: Minimal technological skills involved in staining techniques.
CO4: Minimal digital skills involved in fungal observation.
CO5: Limited technological application in understanding classical experiments.
CO6: Some technological skills may be involved in fermentation processes.
CO7: Potential use of digital tools in microbiological testing and analysis.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy:

CO1: Focus is on technical skills rather than multicultural competence.
CO2: Observation of microorganisms does not directly involve multicultural aspects.
CO3: Staining techniques are more technical than multicultural.
CO4: Fungal observation does not involve multicultural elements.
CO5: Historical experiments do not directly relate to multicultural competence.
CO6: Fermentation skills are technical, with limited direct impact on multicultural competence.
CO7: Microbiological techniques are technical, with limited impact on multicultural competence.

PO11: Value Inculcation and Environmental Awareness:

CO5: Understanding historical experiments has moderate relevance to values in science.
CO6: Preparation of fermented foods can have environmental implications and sustainability aspects.
CO7: Performing microbiological tests can have implications for environmental monitoring and safety.

PO12: Autonomy, Responsibility, and Accountability:

CO1: Requires responsibility in handling and maintaining microscopes.
CO2: Involves responsibility for accurate microorganism observation and reporting.
CO3: Involves autonomy in applying staining techniques accurately.
CO4: Requires responsibility in performing and analyzing wet mounting of fungi. CO5: Requires responsibility in understanding and applying classical microbiological principles.
CO6: Involves autonomy and responsibility in preparing and managing fermentation processes.
CO7: Requires responsibility and accountability in conducting and analyzing various microbiological tests.

PO13: Community Engagement and service:

CO6: Skills in fermentation may have implications for community health and food security.
CO7: Microbiological testing and analysis can impact community health through quality control.

Name of the Programme	**: B.Sc Microbiology**
Programme Code	**: USMI**
Class	**: S.Y.B.Sc.**
Semester	**: IV**
Course Type	**: Skill Enhancement Course (Practical)**
Course Code	**: MIB-276-SEC**
Course Title	**:Practicals on Dairy Microbiology**
No. of Credits	**: 02**
No. of Teaching Hours	**: 60**

Course Objectives:

1. To provide students with the skills necessary to assess milk safety and quality using various tests, such as the Phosphatase and MBRT tests.
2. To train students in detecting mastitis in dairy animals using specialized tests, contributing to animal health and milk safety.
3. To equip students with the ability to estimate milk fat content and perform standard plate counts for both milk and milk powder.
4. To develop students' proficiency in conducting direct microscopic counts and somatic cell counts, important for evaluating milk hygiene and quality.
5. To teach students how to detect common adulterants in milk, such as water, urea, starch, detergent, and formalin, ensuring milk purity.
6. To guide students in the preparation of fermented milk products, specifically curd, enhancing their understanding of dairy fermentation processes.
7. To provide students with real-world experience through a visit to a dairy, followed by the preparation of a detailed visit report.

Course Outcomes:

CO1 Students will demonstrate the ability to perform and interpret the Phosphatase and MBRT tests to evaluate milk safety and quality.
CO2 Students will be able to accurately conduct and interpret mastitis tests, contributing to the health management of dairy animals.
CO3 Students will gain expertise in estimating milk fat content and conducting standard plate counts for both milk and milk powder, essential for quality control.
CO4 Students will proficiently perform direct microscopic counts and somatic cell counts, enabling them to assess milk hygiene and quality.
CO5 Students will acquire the ability to detect various adulterants in milk, ensuring they can assess the purity and safety of dairy products.
CO6 Students will successfully prepare fermented milk products, such as curd, and understand the microbial processes involved in dairy fermentation.
CO7 Students will develop the ability to critically analyze and document their observations from a dairy visit, demonstrating their understanding of dairy operations and reporting skills.

Sr.No.	Name of Experiments	Teaching Hours
	Tests for Analysis of Milk	
1	Phosphatase Test	4
2	MBRT Test	4
3	Mastitis Test	4
4	Milk Fat Estimation Test	4
5-6	Standard Plate Count a. Milk b. Milk Powder	8
7	Direct Microscopic Count	4
8	Somatic Cell Count	4
9-13	Milk Adulteration Test for: a. Water b. Urea c. Starch d. Detergent e. Formalin	20
14	Preparation of fermented milk products- Curd	4
15	Visit to a dairy & preparation of visit report	4
	Total	**60**

References :

1. Smith, S., & Sherman, N. (2019). Dairy Microbiology: A Practical Approach. John Wiley
& Sons
2. Quigley, L., & O'Sullivan, O. (Eds.). (2017). Dairy Microbiology and Biochemistry:
Recent Developments. Nova Science Publishers.
3. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). Modern Food Microbiology (7th ed.).
Springer.
4. Tamime, A. Y. (Ed.). (2008). Probiotic Dairy Products (2nd ed.). John Wiley & Sons.
5. Sudha, M. L., & Reddy, S. Y. (2019). Food Safety and Quality in Dairy Industry. Springer.

6. Hui, Y. H. (Ed.). (2008). Handbook of Food Science, Technology, and Engineering: Dairy
Science, Eggs, Meat, Poultry, and Seafood (Vol. 2). CRC Press.
7. Andrews, A. T. (Ed.). (2017). Food Safety Regulatory Compliance: Catalyst

Mapping of Program Outcomes with Course Outcomes

Class : S.Y.B.Sc (Sem IV) **Subject: Microbiology**

Course : Dairy Microbiology **Course Code : MIB-276-SEC**

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

Course Outcomes	Programme Outcomes (POs)												
	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							2		1		
CO 2													
CO 3				2						1			
CO 4			2				2						
CO 5								2	2				
CO 6													2
CO 7					3								

Justification of Mapping

PO1: Assesing milk safety & quality

Assessing milk safety requires a strong understanding of microbiological and biochemical principles, justifying a strong relationship.

CO1: Students will demonstrate the ability to perform and interpret the Phosphatase and MBRT tests to evaluate milk safety and quality

PO2: Practical, professional, and procedural

Performing Phosphatase and MBRT tests is highly procedural and requires practical skills, leading to a direct relation.

CO1: Students will demonstrate the ability to perform and interpret the Phosphatase and MBRT tests to evaluate milk safety and quality

PO3 : Entrepreneurial Mindset and Knowledge

Although milk safety is critical in the dairy industry, this outcome only tangentially connects to entrepreneurship.

CO4:Students will proficiently perform direct microscopic counts and somatic cell counts, enabling them to assess milk hygiene and quality.

PO4: Specialized Skills and competencies

These tests are specialized skills in dairy microbiology, justifying a strong correlation.

CO3: Students will gain expertise in estimating milk fat content and conduct standard plate counts for both milk and milk powder, essential for quality control.

PO5: Capacity for Application, Problem-Solving

Interpreting test results to ensure milk safety involves problem-solving, justifying a strong relationship.

CO7: Students will develop the ability to critically analyze and document their observations from a dairy visit, demonstrating their understanding of dairy operations and reporting skills

PO6: Communication Skill and Collaboration
Communicating test results and collaborating in a lab setting are moderately related.
PO7: Research-related Skills
Conducting these tests could contribute to research, though not the primary focus, justifying a moderate relationship.
CO7: Students will develop the ability to critically analyze and document their observations from a dairy visit, demonstrating their understanding of dairy operations and reporting skills
PO8: Learning How to Learn Skills
Learning to perform and interpret new tests moderately relates to this outcome.
CO5: Students will acquire the ability to detect various adulterants in milk, ensuring they can assess the purity and safety of dairy products
PO9: Digital and Technological Skill Use of certain technologies and digital tools for these tests
CO4:Students will gain expertise in estimating milk fat content and conducting standard plate counts for both milk and milk powder, essential for quality control
CO5:Students will proficiently perform direct microscopic counts and somatic cell counts, enabling them to assess milk hygiene and quality.

CO6:Students will acquire the ability to detect various adulterants in milk, ensuring they can assess the purity and safety of dairy products
PO10 : Multicultural Competence, Inclusive Spirit, and Empathy
Limited direct connection with multicultural competence or empathy.
PO11: Value Inculcation and Environmental Awareness
Ensuring safe milk directly relates to public health and environmental responsibility, leading to a strong relationship.
CO1: Students will demonstrate the ability to perform and interpret the Phosphatase and MBRT tests to evaluate milk safety and quality
PO12: Autonomy, Responsibility, and Accountability
Conducting safety tests involves a degree of responsibility, but it's not the main focus, leading to a moderate relation.
PO13: Community Engagement and Service
While ensuring milk safety indirectly benefits the community, it has a weak direct connection.
CO6: Students will successfully prepare fermented milk products, such as curd, and understand the microbial processes involved in dairy fermentation