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|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Estd. 1962<br>"A++" Accredited by<br>NAAC (2021)<br>With CGPA 3.52 | <b>SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA</b><br>PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in<br><b>शिवाजी विद्यापीठ, कोल्हापूर - ४१६००४, महाराष्ट्र</b><br>दूरध्वनी-ईपीएबीएक्स - २६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१-२६०९०९४<br>०२३१-२६०९४८७ |   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Ref.No.SU/BOS/Science/148

Date: 26/05/2026

The Principal,  
 All Concerned Affiliated Colleges/Institutions  
 Shivaji University, Kolhapur.

**Subject:** Regarding revised syllabi of B.Sc. Part-III (Sem.V & VI) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0)

**Sir/Madam,**

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the syllabi, nature of question paper of B.Sc. Part-III (Sem.V & VI) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0).

| B.Sc. Part-III (Sem. V & VI) as per NEP-2020 (2.0) |                             |     |                                     |
|----------------------------------------------------|-----------------------------|-----|-------------------------------------|
| 1.                                                 | Botany                      | 9.  | Geology                             |
| 2.                                                 | Physics                     | 10. | Zoology                             |
| 3.                                                 | Statistics                  | 11. | Chemistry                           |
| 4.                                                 | Mathematics                 | 12. | Electronics                         |
| 5.                                                 | Microbiology                | 13. | Drug Chemistry                      |
| 6.                                                 | Industrial Microbiology     | 14. | Pollution                           |
| 7.                                                 | Biochemistry                | 15. | Food Science and Quality Control    |
| 8.                                                 | Computer Science (Optional) | 16. | Biotechnology (Optional/Vocational) |

This syllabus, nature of question and equivalence shall be implemented from the academic year 2026-2027 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website [www.unishivaji.ac.in](http://www.unishivaji.ac.in)>Syllabus>Syllabus as per NEP2020.

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2026 & March/April 2027. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,



Dy Registrar

Encl: as above

for information and necessary action

Copy to:

|   |                                                |    |                                 |
|---|------------------------------------------------|----|---------------------------------|
| 1 | Dean, Faculty of Science & Technology          | 6  | Appointment Section A & B       |
| 2 | Director, Board of Examinations and Evaluation | 7  | I.T.Cell /Computer Centre       |
| 3 | Chairman, Respective Board of Studies          | 8  | Eligibility Section             |
| 4 | B.Sc.-M.Sc. Exam Section                       | 9  | Affiliation Section (T.1) (T.2) |
| 5 | Internal Quality Assurance Cell (IQAC Cell)    | 10 | P.G. Seminar Section            |

# **SHIVAJI UNIVERSITY, KOLHAPUR**



**Established: 1962**

**A<sup>++</sup> Accredited by NAAC (2021) with CGPA 3.52**

**NEW SYLLABUS FOR**

**B. Sc. Part III**

**INDUSTRIAL MICROBIOLOGY**

**Semester V and VI**

**(Faculty of Science and Technology)**

**Structure and Syllabus in Accordance with  
National Education Policy - 2020 (NEP 2.0)**

**with Multiple Entry and Multiple Exit**

**(To be implemented from Academic Year 2026-27)**

**1. Year of Implementation:** Revised Syllabus will be implemented from June, 2026 onwards.

**2. Preamble:**

This syllabus is framed to give sound knowledge with understanding of Industrial Microbiology to undergraduate students at Third year of three years of B.Sc. degree course. Students learn Industrial Microbiology as a separate subject from B.Sc. I to B.Sc. III. The goal of the syllabus is to make the study of Industrial Microbiology popular, interesting and encouraging to the students for higher studies including research. The new and updated syllabus is based on a basic and applied approach with vigor and depth. At the same time, precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of industries and research. The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields. The units of the syllabus are well defined, taking into consideration the level and capacity of students.

**3. Programme Objectives**

- 1. To provide in-depth knowledge of Industrial Microbiology** including microbial physiology, genetics, fermentation technology, and industrial applications in pharmaceuticals, food, agriculture, and environment.
- 2. To develop practical and technical skills** in microbiological techniques such as isolation, identification, cultivation, preservation, and large-scale production of microorganisms.
- 3. To train students in industrial processes and bioprocess technology**, including fermentation, downstream processing, and production of microbial metabolites like antibiotics, enzymes, vaccines, and biofertilizers.
- 4. To impart knowledge of quality control, quality assurance, and regulatory standards** (IP, WHO, GMP) applicable to pharmaceutical, food, and agricultural microbiology industries.
- 5. To enhance research aptitude and scientific thinking** through experimental design, data analysis, molecular biology techniques, and problem-solving in microbiology.
- 6. To develop awareness of environmental microbiology and sustainability**, including waste management, bioremediation, and ecological balance.

7. **To promote interdisciplinary learning** by integrating biotechnology, molecular biology, bioinformatics, and industrial applications.
8. **To equip students with professional, communication, and entrepreneurial skills** required for careers in industries, research, and startups.
9. **To inculcate ethical practices, biosafety, and social responsibility** in handling microorganisms and industrial processes.
10. **To prepare students for higher education and career opportunities** in microbiology, biotechnology, pharmaceuticals, food industries, and environmental sectors.

#### **4. Programme Outcomes (POs)**

##### **PO1: Disciplinary Knowledge**

Apply comprehensive knowledge of industrial microbiology, including microbial processes, fermentation technology, and biotechnology applications.

##### **PO2: Laboratory and Technical Skills**

Perform microbiological techniques such as culturing, staining, biochemical testing, fermentation, molecular methods (PCR, electrophoresis), and quality testing.

##### **PO3: Industrial and Bioprocess Understanding**

Understand and apply principles of industrial production of microbial products like antibiotics, enzymes, vaccines, fermented foods, and biofertilizers.

##### **PO4: Quality Control and Regulatory Competence**

Apply microbiological quality control methods (TAMC, TYMC, sterility testing) and understand regulatory standards (IP, WHO, GMP).

##### **PO5: Research and Analytical Skills**

Design experiments, analyze data, interpret results, and apply scientific reasoning to solve microbiological and industrial problems.

##### **PO6: Environmental and Sustainability Awareness**

Evaluate environmental issues and apply microbiological solutions such as bioremediation, waste treatment, and sustainable practices.

##### **PO7: Critical Thinking and Problem Solving**

Identify industrial and environmental problems and develop innovative microbiological solutions.

**PO8: Communication and Teamwork**

Communicate scientific information effectively and work collaboratively in laboratory and industrial settings.

**PO9: Professional Ethics and Safety**

Demonstrate ethical practices, biosafety, and professional responsibility in laboratory and industrial environments.

**PO10: Employability and Entrepreneurship**

Utilize technical and digital skills for employment in microbiology-based industries or develop entrepreneurial ventures.

**5. Programme Specific Outcomes (PSOs)****PSO1: Fundamental and Applied Knowledge of Industrial Microbiology**

Understand basic, advanced, and applied concepts of Industrial Microbiology including medical, industrial, environmental, agricultural, food, and genetic applications of microorganisms.

**PSO2: Laboratory and Technical Skills**

Demonstrate competency in microbiological laboratory techniques, operation of instruments, aseptic handling, fermentation practices, and industrial microbiological procedures required in research and industrial laboratories.

**PSO3: Industrial Production and Bioprocess Understanding**

Acquire knowledge of microbial production processes such as antibiotics, vaccines, fermented products, beverages, recombinant products, and other industrially important microbial metabolites.

**PSO4: Analytical, Problem-Solving and Research Ability**

Develop analytical thinking and research aptitude to identify industrial and societal problems and apply microbiological principles for designing innovative and sustainable solutions.

**PSO5: Professional Competence and Career Readiness**

Develop professional skills, scientific attitude, and industrial awareness necessary for careers in microbiology-based industries, quality control laboratories, research organizations, and higher education.

**6. Course Outcomes (COs):**

Course outcomes are specified in the respective syllabus for each course.

**7. Duration of the Program:** The course shall be a full-time course.

**8. Medium of Instruction:** English

**9. Eligibility for Admission:** The criterion for admission is as per the rules and regulations set from time to time by concerned departments, HEIs, university, government, and other relevant statutory authorities.

**10. Scheme of Teaching and Examination Pattern (Theory/Practical/Internal):**

- The scheme of teaching and examination for the programme of study shall be as approved by the Academic Council / Board of Studies.
- The pattern of examination shall consist of a Semester-End Examination along with Internal Assessment.
- Each theory course of 2 credit shall carry 50 marks (40 marks for the Semester-End Examination and 10 marks for Internal Assessment).
- The rule for practical examination shall be as per the circular/ letter issued by respective Board of Studies.
- The examination pattern for On Job Training (OJT) and Field Project (FP) shall be as per the University guidelines.

**11. Programme Structure**

| SHIVAJI UNIVERSITY, KOLHAPUR                                                                           |                                                                           |                                                    |          |                      |                                                                      |                                                             |                 |                  |                             |
|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------|----------|----------------------|----------------------------------------------------------------------|-------------------------------------------------------------|-----------------|------------------|-----------------------------|
| NEP-2020 (2.0): Credit Framework for UG (B. Sc. III) Programme under Faculty of Science and Technology |                                                                           |                                                    |          |                      |                                                                      |                                                             |                 |                  |                             |
| SEM<br>(Level)                                                                                         | COURSES                                                                   |                                                    |          | OE                   | VSC/ SEC                                                             | AEC/VEC/<br>IKS                                             | AEC/VEC/<br>IKS | Total<br>Credits | Degree/<br>Cum. Cr.<br>MEME |
|                                                                                                        | Course-1                                                                  | Course-2                                           | Course-3 |                      |                                                                      |                                                             |                 |                  |                             |
| SEM V<br>(5.5)                                                                                         | Major IX (2)<br>Major X (2)<br>Major P V (a) (2)<br>Major P V (b) (2)     | Major I<br>(ELEC) (2)<br>Major P I<br>(ELEC) (2)   | -        | OE-5<br>(2)<br>(T/P) | VSC II (2)<br>(Major<br>specific)<br>(P)                             | AEC III (2)<br>(English)                                    | OJT<br>(04)     | 22               | UG<br>Degree<br>132         |
| SEM VI<br>(5.5)                                                                                        | Major XI (2)<br>Major XII (2)<br>Major P VI (a) (2)<br>Major P VI (b) (2) | Major II<br>(ELEC) (2)<br>Major P II<br>(ELEC) (2) | -        | -                    | VSC III<br>(2)<br>(Major<br>specific)<br>(P)<br>SEC III (2)<br>(T/P) | AEC IV (2)<br>(English)<br>IKS 2 (2)<br>(Major<br>specific) | FP<br>(02)      | 22               |                             |
| Credits                                                                                                | 8(T)+8(P)=16                                                              | 4(T)+4(P)=8                                        |          | 2(T/P)               | 2(T/P) +<br>4(P) = 6                                                 | 2+4 = 6                                                     | 4+2 = 6         | 44               |                             |

## 12. Equivalence in accordance with titles and contents of papers for revised syllabus

| Sr. No. | Title of Old Paper                                                                         | Title of New Paper                                                                                                       |
|---------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| 1       | <b>Course-IX -DSE E 27:</b><br>Environmental Microbiology                                  | <b>Major Course IX:</b><br>Environmental Microbiology                                                                    |
| 2       | <b>Course-X- DSE E 28:</b><br>Basic Techniques of Biotechnology                            | <b>Major Course X:</b><br>Basic Techniques in Biotechnology                                                              |
| 3       | <b>Course-XI-DSE E 29:</b><br>Quality Assurance and Quality Control in Industrial Products | <b>Major Course I A (Elective):</b><br>Quality Assurance and Control in Industrial Products                              |
| 4       | <b>Course-XII DSE E 30:</b><br>Microbial Production of Metabolites and Bioinsecticides     | <b>Major Course I B (Elective):</b><br>Microbial Production of Metabolites and Bioinsecticides                           |
| 5       | <b>Course- XIII DSE F 27:</b><br>Environmental Pollution and Control                       | <b>Major Course XI:</b><br>Environmental Pollution and Control                                                           |
| 6       | <b>Course- XIV DSE F 28:</b><br>Applications of Biotechnology                              | <b>Major Course XII:</b><br>Applications of Biotechnology                                                                |
| 7       | <b>Course- XV DSE F 29:</b><br>Industrial Management,<br>Government Laws and Regulations   | <b>Major Course II A (Elective):</b><br>Quality Control, Standards and Regulatory Framework in Agricultural Microbiology |
| 8       | <b>Course- XVI DSE F 30:</b><br>Microbial Fermentations, Foods and Biofuels                | <b>Major Course II B (Elective):</b><br>Microbial Fermentations, Foods and Biofuels                                      |

## 13. Standard of Passing

- The standard of passing shall be as shown in the table below:

|                                    | Semester-End Examination | Internal Assessment | Course Exam (Total) |
|------------------------------------|--------------------------|---------------------|---------------------|
| Maximum Marks                      | 40                       | 10                  | 50                  |
| Minimum Marks required for passing | 14                       | 4                   | 18                  |

- There shall be a separate head of passing for the Semester-End Examination and the Internal Assessment for each theory course.
- A student must obtain a minimum of 14 marks out of 40 in the Semester-End Examination and 4 marks out of 10 in the Internal Assessment to pass the theory course.
- For practical courses carrying 50 marks, a student must obtain a minimum of 18 marks to pass the examination. For practical courses carrying 100 marks, a student must obtain a minimum of 35 marks to pass the examination.
- Passing criteria for On Job Training (OJT) and Field Project (FP) shall be as per the University guidelines.

#### **14. Nature of Question Paper, Duration and Scheme of Marking:**

##### **A) Theory Examinations**

- a) Maximum Marks : 40
- b) Duration : 1 hr 30 min
- c) Nature of the Theory Examination Question Paper and Scheme of Marking

| Question No.       | Nature/Type of Question                                             | Marks                                   |
|--------------------|---------------------------------------------------------------------|-----------------------------------------|
| 1                  | Multiple Choice Questions (MCQs)<br>(8 Questions)                   | 8 Marks<br>(1 Mark for Each Question)   |
| 2                  | Broad Answer/Descriptive Type Questions<br>(Attempt Any 2 Out of 3) | 16 Marks<br>(8 Marks for Each Question) |
| 3                  | Short Note Type Questions<br>(Attempt Any 4 Out of 6)               | 16 Marks<br>(4 Marks for Each Question) |
| <b>Total Marks</b> |                                                                     | <b>40</b>                               |

##### **B) Practical Examinations**

- a) The examination of the Major Practical Course shall carry 150 marks per semester (Major Mandatory – 100 marks and Major Elective – 50 marks). It shall be conducted over three consecutive days, with a minimum duration of six hours per day.
- b) The Practical Examination for Vocational Skill Courses (VSC–II and VSC–III), Skill Enhancement Course (SEC–III), and Open Elective Course (OE–5) shall carry 50 marks each. These examinations shall be conducted separately over two consecutive days, with a minimum duration of three hours per day.
- c) Each candidate must produce a certificate from the Head of the Department of the respective college stating that the candidate has satisfactorily completed the practical course in accordance with the guidelines laid down by the Academic Council on the recommendations of the Board of Studies and that the laboratory journal has been properly maintained. Every candidate must record observations in the laboratory journal and prepare a report for each exercise performed. The journal shall be checked and signed periodically by a member of the teaching staff and certified by the Head of the Department at the end of the semester. Candidates must produce their certified journals at the time of the practical examination.
- d) The nature of question paper and scheme of marking are provided at the end of syllabus.



## Structure of B. Sc. Part III Industrial Microbiology

| SEM<br>(Level)  | Course Code    | Course Name                                                                                                              | No. of<br>Credits |
|-----------------|----------------|--------------------------------------------------------------------------------------------------------------------------|-------------------|
| SEM V<br>(5.5)  | MM-L-3-21-E-9  | Major Course IX: Environmental Microbiology                                                                              | 2                 |
|                 | MM-L-3-21-E-10 | Major Course X: Basic Techniques in Biotechnology                                                                        | 2                 |
|                 | ME-L-3-21-E-1a | Major Course I A (Elective): Quality Assurance and Control in Industrial Products                                        | 2                 |
|                 | ME-L-3-21-E-1b | <b>OR</b><br>Major Course I B (Elective): Microbial Production of Metabolites and Bioinsecticides                        |                   |
|                 | MM-P-3-21-E-5a | Major Practical Course V (a): Environmental microbiology                                                                 | 2                 |
|                 | MM-P-3-21-E-5b | Major Practical Course V (b): Basic Techniques in Biotechnology                                                          | 2                 |
|                 | ME-P-3-21-E-1a | Major Practical Course I A (Elective): Quality Assurance and Control in Industrial Products                              | 2                 |
|                 | ME-P-3-21-E-1b | <b>OR</b><br>Major Practical Course I B (Elective): Microbial Production of Metabolites and Bioinsecticides              |                   |
|                 | VSC-P-3-21-E-2 | VSC II: Food Testing and Quality Control- I                                                                              | 2                 |
|                 | OE-P-3-21-E-5  | OE 5: Introduction to Soil Science and Soil Microbiology                                                                 | 2                 |
|                 |                | OJT: On Job Training                                                                                                     | 4                 |
|                 |                | AEC III: English                                                                                                         | 2                 |
| SEM VI<br>(5.5) | MM-L-3-21-F-11 | Major Course XI: Environmental Pollution and Control                                                                     | 2                 |
|                 | MM-L-3-21-F-12 | Major Course XII: Applications of Biotechnology                                                                          | 2                 |
|                 | ME-L-3-21-F-2a | Major Course II A (Elective): Quality Control, Standards and Regulatory Framework in Agricultural Microbiology           | 2                 |
|                 | ME-L-3-21-F-2b | <b>OR</b><br>Major Course II B (Elective): Microbial Fermentations, Foods and Biofuels                                   |                   |
|                 | MM-P-3-21-F-6a | Major Practical Course VI (a): Environmental pollution and control                                                       | 2                 |
|                 | MM-P-3-21-F-6b | Major Practical Course VI (b): Applications of Biotechnology                                                             | 2                 |
|                 | ME-P-3-21-F-2a | Major Practical Course II A (Elective): Quality Control, Standards and Regulatory Framework in Agricultural Microbiology | 2                 |
|                 | ME-P-3-21-F-2b | <b>OR</b><br>Major Practical Course II B (Elective): Microbial Fermentations, Foods and Biofuels                         |                   |
|                 | VSC-P-3-21-F-3 | VSC III: Food Testing and Quality Control- II                                                                            | 2                 |
|                 | SEC-P-3-21-F-3 | SEC III: Microbial Quality Assurance in Pharmaceutical Industries                                                        | 2                 |
|                 | IKS-L-3-21-F-2 | IKS 2: Indian Knowledge System in Microbiology                                                                           | 2                 |
|                 |                | FP: Field Project                                                                                                        | 2                 |
|                 |                | AEC IV: English                                                                                                          | 2                 |
|                 |                | <b>Total Credits</b>                                                                                                     | <b>44</b>         |

**B. Sc. Part III**  
**Industrial Microbiology**  
**Semester V**

## **MAJOR COURSE IX: ENVIRONMENTAL MICROBIOLOGY**

**(Credit-2, Total Lectures- 30)**

### **Course Objectives**

The course is designed to:

1. To introduce students to the significance of microorganisms in different environmental systems, particularly soil and aquatic environments.
2. To develop understanding of microbial participation in major elemental (biogeochemical) cycles such as carbon, nitrogen, and phosphorus cycles.
3. To familiarize students with the diversity and functions of microorganisms in specialized environments, including petroleum and marine ecosystems.
4. To provide knowledge about industrial applications of environmental microorganisms, especially in bioleaching processes and the textile industry, along with microbial deterioration and its prevention.

### **Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain the physical, chemical, and biological characteristics of soil environment and describe microbial interactions contributing to soil fertility.
2. Describe the role of microorganisms in major elemental cycles, including carbon, nitrogen, and phosphorus cycles, and their environmental importance.
3. Discuss the diversity and ecological roles of microorganisms in petroleum and marine environments, including hydrocarbon degradation processes.
4. Explain the principles and applications of microorganisms in bioleaching and textile industries, including microbial deterioration of fibers and preventive measures.

### **Unit I/ Credit I**

**Lectures – 15**

#### **A) SOIL ENVIRONMENT**

- a. Introduction, physical, chemical, microbial characters.
- b. Microbial interactions in soil & their role in soil fertility

#### **B) ELEMENTAL CYCLES**

- a) Role of microorganisms in elemental cycles
- b) Carbon cycle, Nitrogen cycle, Phosphorus cycle

### **Unit II /Credit II**

**Lectures - 15**

#### **A) MICROORGANISMS IN VARIOUS ENVIRONMENTS**

- a) Petroleum Microbiology:
  1. Types of compounds in petroleum.
  2. Role of microorganisms in hydrocarbon degradation.
- b) Marine Microbiology:
  1. Characters of marine environment.
  2. Role of marine microorganisms.

- c) Astro microbiology (space capsule):
  - 1. Characteristics of space environment.
  - 2. Microorganisms in the astro-environment.
  - 3. Characteristics of microbes.

## B) ROLE OF MICROORGANISMS IN BIOLEACHING AND TEXTILE INDUSTRY

- a) Bioleaching of elements
  - 1. Introduction, microorganisms involved,
  - 2. Chemistry of microbial leaching and beneficiation
  - 3. Leaching methods – Laboratory and in situ leaching of copper and uranium.
- b) Textile Industry
  - 1. Types of destruction caused by microorganisms from cotton & its prevention.
  - 2. Types of destruction caused by microorganisms from wool & its prevention.

## References

1. Environmental Microbiology – Ian L. Pepper, Charles P. Gerba & Terry J. Gentry – 3<sup>rd</sup> Edition – Academic Press.
2. Microbial Ecology – Larry L. Barton & Diana E. Northup – 1<sup>st</sup> Edition – Wiley-Blackwell.
3. Soil Microbiology – N. S. Subbarao – 4<sup>th</sup> Edition – Oxford & IBH Publishing Co.
4. Modern Soil Microbiology – Jan Dirk van Elsas, J. Trevor Trevors & Elaine M. H. Wellington – 2<sup>nd</sup> Edition – CRC Press.
5. Nature and Properties of Soils – Nyle C. Brady & Ray R. Weil – 14<sup>th</sup> Edition – Pearson Education.
6. Microbiology – Michael J. Pelczar Jr., E. C. S. Chan & Noel R. Krieg – 5<sup>th</sup> Edition – Tata McGraw-Hill.
7. Microbial Biogeochemistry – Alexander I. Zajic – 1<sup>st</sup> Edition – Academic Press.
8. Methods in Environmental Analysis: Water, Soil and Air – P. K. Gupta – 2<sup>nd</sup> Edition – Agrobios (India).
9. Marine Microbiology: Ecology and Applications – Colin Munn – 2<sup>nd</sup> Edition – Garland Science.
10. Petroleum Microbiology – R. M. Atlas – 1<sup>st</sup> Edition – Macmillan Publishers.
11. Geomicrobiology – Henry L. Ehrlich & Dianne K. Newman – 5<sup>th</sup> Edition – CRC Press.
12. Environmental Biotechnology – A. K. Chatterjee – 1<sup>st</sup> Edition – Prentice Hall India.
13. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
14. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
15. Astrobiology: A Brief Introduction – Kevin W. Plaxco & Michael Gross – 2<sup>nd</sup> Edition – Johns Hopkins University Press.

# **MAJOR COURSE X: BASIC TECHNIQUES IN BIOTECHNOLOGY**

## **(Credit-2, Total Lectures- 30)**

### **Course Objectives**

The course is designed to:

1. To introduce students to the fundamental principles and procedures of basic biotechnology and genetic engineering techniques.
2. To develop understanding and analytical skills for interpretation of molecular biology data, including DNA sequencing and protein expression analysis.
3. To familiarize students with major molecular and biotechnological techniques and their applications in medicine, agriculture, industry, and environmental conservation.
4. To provide knowledge about genetically modified organisms, gene engineering, and protein engineering, and their significance in improving human life.

### **Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain basic concepts of genetic engineering, including tools, cloning vectors, cloning organisms, and recombinant DNA technology.
2. Describe techniques involved in genetic manipulation, such as DNA isolation, construction of recombinant DNA, gene transfer methods, and selection of recombinants.
3. Discuss molecular biology techniques used for detection and analysis of nucleic acids and proteins, including blotting methods, DNA sequencing, gene editing, and CRISPR-Cas technology.
4. Explain principles and applications of protein engineering and PCR, and evaluate their advantages, limitations, and applications in biotechnology.

### **Unit I / Credit I**

**Lectures - 15**

#### **A) BASIC CONCEPT OF GENETIC ENGINEERING**

##### **a. Introduction**

##### **b. Tools of genetic engineering -**

##### **1. Enzymes –**

- Restriction enzymes- Definition, types (I, II, III), nomenclature, recognition sequences, cleavage patterns
- Other enzymes- T4 DNA ligase, Alkaline phosphatase, Polynucleotide kinase, Terminal Transferase, Reverse transcriptase, DNA polymerase I, Taq DNA polymerase, RNase H, Exonuclease III, S1 nuclease and Mung bean nuclease

##### **2. Cloning Vectors –**

- Plasmids- pBR322 and pUC 19
- Phage -lambda phage
- Cosmid and Phagemid
- Artificial chromosome - YAC and BAC

- Animal vectors – Retroviruses
  - Plant vector – Ti plasmid
3. Cloning organisms-
    - Bacteria- *Bacillus* and *E. coli*
    - Yeast- *Saccharomyces cerevisiae*
  4. The concept of Genomic library and cDNA library

## Unit II/ Credit II

## Lectures - 15

### A) TECHNIQUES IN GENETIC ENGINEERING

1. Isolation of Gene - Chemical synthesis, Isolation of specific gene with PCR, cDNA synthesis, Shotgun method.
2. Construction of rDNA using appropriate vector- Use of restriction enzymes, linkers, adapters, Homopolymer tails.
3. Transfer of rDNA into cloning organisms (Bacteria and Yeast)- Transformation, Electroporation, PEG treatment
4. Selection of recombinant bacteria and yeast- Blue White Screening and Colony Hybridization Technique.

### B) TECHNIQUES IN MOLECULAR BIOLOGY

Principle, Methods and Applications of:

1. DNA Sequencing – Sanger's method
2. Blotting Technique –
  - a) Southern Blotting
  - b) Northern Blotting
  - c) Western blotting
  - d) DOT Blot Technique
3. Gene editing - CRISPR-CAS technique
4. Techniques of Detection and Analysis of Nucleic Acid
  - a) Radioactive labelling – Nick translation,
  - b) Non-radioactive labelling – Horse Radish Peroxide (HRP) method
5. DNA Fingerprinting
6. PCR

### References

1. Principles of Gene Manipulation and Genomics – Sandy B. Primrose & Richard Twyman – 7<sup>th</sup> Edition – Blackwell Publishing.
2. Gene Cloning and DNA Analysis – T. A. Brown – 7<sup>th</sup> Edition – Wiley-Blackwell.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA – Bernard R. Glick, Jack J. Pasternak & Cheryl L. Patten – 5<sup>th</sup> Edition – ASM Press.
4. Recombinant DNA Technology – A. Chakravarty – 1<sup>st</sup> Edition – CBS Publishers & Distributors.
5. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
6. Textbook of Biotechnology – R. C. Dubey – 5<sup>th</sup> Edition – S. Chand & Company Ltd.

7. Genetic Engineering – S. Rastogi & N. Pathak – 2<sup>nd</sup> Edition – Oxford University Press.
8. Molecular Biology of the Gene – James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine & Richard Losick – 7<sup>th</sup> Edition – Pearson Education.
9. Biotechnology – U. Satyanarayana – 1<sup>st</sup> Edition – Books and Allied (P) Ltd.
10. Genomes – T. A. Brown – 4<sup>th</sup> Edition – Garland Science.
11. Molecular Cloning: A Laboratory Manual – Joseph Sambrook & David W. Russell – 3<sup>rd</sup> Edition – Cold Spring Harbor Laboratory Press.
12. Principles of Genetics – D. Peter Snustad & Michael J. Simmons – 6<sup>th</sup> Edition – Wiley India.
13. Introduction to Genetic Engineering – Desmond S. T. Nicholl – 3<sup>rd</sup> Edition – Cambridge University Press.
14. Biochemistry and Molecular Biology – William H. Elliot & Daphne C. Elliot – 4<sup>th</sup> Edition – Oxford University Press.
15. PCR Technology: Principles and Applications for DNA Amplification – Henry A. Erlich – 1<sup>st</sup> Edition – Stockton Press.

**MAJOR COURSE I A (ELECTIVE):**  
**QUALITY ASSURANCE AND CONTROL IN INDUSTRIAL PRODUCTS**  
**(Credit-2, Total Lectures- 30)**

**Course Objectives**

The course is designed to:

1. To introduce students to the principles and concepts of quality assurance and quality control in pharmaceutical and industrial products with reference to pharmacopeial and regulatory requirements.
2. To develop understanding of microbiological quality testing and assay procedures used for evaluation of pharmaceutical products according to Indian pharmacopeial standards.
3. To provide knowledge of quality control testing methods including sterility, pyrogenicity, toxicity, mutagenicity, carcinogenicity, and allergy testing for ensuring product safety and efficacy.
4. To familiarize students with international quality standards and validation procedures used in pharmaceutical industries, including in-process monitoring and validation of sterilization systems and laminar airflow cabinets.

**Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain the concepts of pharmacopoeia, regulatory authorities, and pharmaceutical product classification, and describe microbiological quality standards as per Indian Pharmacopoeia.
2. Perform and interpret microbiological quality tests, including microbial limit tests (TAMC, TYMC) and detection of specified microorganisms in pharmaceutical products.
3. Describe various quality control tests used to ensure safety and efficacy of pharmaceutical products, including sterility, pyrogen, toxicity, mutagenicity, carcinogenicity, and allergy testing.
4. Discuss international quality standards and validation procedures such as WHO and ISI guidelines, in-process monitoring, sterilization validation, and laminar air flow cabinet validation.

**Unit I/ Credit I**

**Lectures - 15**

**A) Indian Pharmacopoeia:**

- a) Introduction
- b) Concept of pharmacopoeia
- c) Concept of regulatory authorities
- d) Types of pharmaceutical products
- e) Microbial Limit Test (MLT) as per Indian Pharmacopoeia, Total Aerobic Microbial Count (TAMC), Total Yeast and Mold Count (TYMC), Test for specified microorganisms - *Escherichia coli*, *Salmonella spp.*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans*.



B) Assay of microbial products as per Indian Pharmacopoeia: - Alcohol & Citric acid

## **Unit II/ Credit II**

**Lectures - 15**

### **A) QUALITY CONTROL TESTS OF PHARMACEUTICAL PRODUCTS**

Sterility test, Pyrogen test, Toxicity test, Carcinogenicity test, Mutagenicity test, Allergy test

### **B) International standards as per WHO, ISI, and validation in pharmaceutical industry**

- a) WHO & ISI standards.
- b) Validation & in-process monitoring of sterilization procedures
- c) Validation of Laminar Air Flow Cabinet

## **References**

1. Indian Pharmacopoeia – Government of India, Ministry of Health and Family Welfare – Latest Edition – Indian Pharmacopoeia Commission.
2. European Pharmacopoeia – European Directorate for the Quality of Medicines – Latest Edition – Council of Europe.
3. United States Pharmacopeia and National Formulary (USP–NF) – United States Pharmacopeial Convention – Latest Edition – USP Convention.
4. Pharmaceutical Microbiology – W. B. Hugo & A. D. Russell – 8<sup>th</sup> Edition – Blackwell Scientific Publications.
5. Pharmaceutical Microbiology – S. S. Purohit, Rajiv Rajan & Kakrani – 1<sup>st</sup> Edition – Agrobios (India).
6. Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials – World Health Organization – 2<sup>nd</sup> Edition – WHO Publications.
7. Quality Control in the Pharmaceutical Industry – Murray S. Cooper – 1<sup>st</sup> Edition – Academic Press.
8. Pharmaceutical Quality Assurance – K. A. Hajamohideen & S. C. Karna – 1<sup>st</sup> Edition – PharmaMed Press.
9. Good Manufacturing Practices for Pharmaceuticals – Sidney H. Willig & James R. Stoker – 5<sup>th</sup> Edition – Marcel Dekker Inc.
10. Microbiological Quality Assurance in Pharmaceuticals, Cosmetics and Toiletries – Rosamund M. Baird, Norman A. Hodges & Stephen P. Denyer – 1<sup>st</sup> Edition – CRC Press.
11. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
12. Pharmacology and Pharmacotherapeutics – R. S. Satoskar, S. D. Bhandarkar & S. S. Ainapure – 24<sup>th</sup> Edition – Popular Prakashan.
13. Sterilization, Disinfection and Infection Control – G. McDonnell – 1<sup>st</sup> Edition – ASM Press.
14. Handbook of Validation in Pharmaceutical Processes – James Agalloco & Frederick J. Carleton – 3<sup>rd</sup> Edition – Informa Healthcare.

**MAJOR COURSE I B (ELECTIVE):**  
**MICROBIAL PRODUCTION OF METABOLITES AND**  
**BIOINSECTICIDES**  
**(Credit-2, Total Lectures- 30)**

**Course Objectives**

The course is designed to:

1. To introduce students to primary and secondary microbial metabolites and their roles in microbial growth, survival, communication, and defense mechanisms.
2. To develop understanding of microbial production processes involved in the synthesis of vitamins, organic acids, antibiotics, and other industrially important metabolites.
3. To familiarize students with applications of microbial metabolites in human and animal health, agriculture, industry, and environmental sustainability.
4. To provide knowledge about microbial bioinsecticides and toxoids, including their production and mechanisms for controlling pests and preventing infectious diseases.

**Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain microbial production of industrially important metabolites, including vitamins, organic acids, and antibiotics, along with organisms used and production processes.
2. Describe fermentation and recovery processes involved in microbial metabolite production and their applications in biotechnology and industry.
3. Discuss the role and mode of action of microbial bioinsecticides, such as *Bacillus thuringiensis* and *Trichoderma*, in biological pest control.
4. Explain the production and applications of toxoids and single-cell protein (SCP) and evaluate their importance in healthcare and nutrition.

**Unit I/ Credit I**

**Lectures - 15**

**A) MICROBIAL PRODUCTION OF VITAMINS:**

- a. Vitamin B12 - Organism used, production method, process, recovery and assay.
- b. Vitamin A - Organism used, production method, process, recovery, and assay

**B) Microbial Production of organic acid**

- a. Gluconic acid
- b. Indole Acetic Acid

**C) Production of Antibiotics:**

- a. Bacitracin
- b. Chloramphenicol

**Unit II/ Credit II**

**Lectures - 15**

**PRODUCTION OF ANTIBIOTICS AND TOXOIDS**

**A) Biopesticides:**

- a. *Bacillus thuringiensis*
  - b. *Trichoderma*
- B) Production of toxoids:
  - a. Diphtheria
  - b. Tetanus
- C) SCP
  - a. Yeast
  - b. Algae

## References

1. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
2. Industrial Microbiology – A. H. Patel – 2<sup>nd</sup> Edition – Macmillan Publishers India Ltd.
3. Fermentation Technology – Stanbury, Whitaker & Hall – 3<sup>rd</sup> Edition – Elsevier Science.
4. Principles of Fermentation Technology – P. F. Stanbury & A. Whitaker – 2<sup>nd</sup> Edition – Pergamon Press.
5. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
6. Textbook of Biotechnology – R. C. Dubey – 5<sup>th</sup> Edition – S. Chand & Company Ltd.
7. Industrial Microbiology – L. E. Casida Jr. – 2<sup>nd</sup> Edition – New Age International Publishers.
8. Microbial Biotechnology – Alexander N. Glazer & Hiroshi Nikaido – 2<sup>nd</sup> Edition – Cambridge University Press.
9. Antibiotics: Origin, Nature and Properties – Selman Waksman – 1<sup>st</sup> Edition – Williams & Wilkins Company.
10. Pharmaceutical Microbiology – W. B. Hugo & A. D. Russell – 8<sup>th</sup> Edition – Blackwell Scientific Publications.
11. Manual of Industrial Microbiology and Biotechnology – Richard H. Baltz, Julian E. Davies & Arnold L. Demain – 3<sup>rd</sup> Edition – ASM Press.
12. Biopesticides and Bioagents – Opendar Koul & G. S. Dhaliwal – 1<sup>st</sup> Edition – Taylor & Francis.
13. Biological Control of Plant Diseases – Samuel S. Gnanamanickam – 1<sup>st</sup> Edition – CRC Press.
14. Food and Industrial Microbiology – M. R. Adams & M. O. Moss – 1<sup>st</sup> Edition – Royal Society of Chemistry.
15. Introduction to Modern Microbiology – Gerard J. Tortora, Berdell R. Funke & Christine L. Case – 11<sup>th</sup> Edition – Pearson Education.

# **MAJOR PRACTICAL COURSE V (a): ENVIRONMENTAL MICROBIOLOGY**

**(Credit-2, Total Lectures- 60)**

## **Course Objectives**

The course is designed to:

1. To develop practical skills in isolation, cultivation, and characterization of environmentally important microorganisms from diverse habitats.
2. To understand microbial diversity and activities associated with cellulose degradation, hydrocarbon biodegradation, compost ecosystems, and saline environments.
3. To learn microbiological techniques for enumeration and analysis of microorganisms from environmental samples.
4. To gain hands-on experience in studying biodegradation processes and estimation of soil nitrogen using the Kjeldahl method.

## **Course Outcomes**

Upon completion of the course, students will be able to:

1. Isolate and cultivate cellulolytic, halophilic, and hydrocarbon degrading microorganisms from environmental samples.
2. Perform microbial enumeration techniques for analysis of compost microbial populations.
3. Evaluate microbial activities involved in cellulose degradation, hydrocarbon biodegradation, and deterioration of cotton fibres.
4. Apply microbiological and analytical techniques for studying environmental microbial processes and soil nutrient analysis.

## **Practical Experiments**

1. Isolation of cellulolytic bacteria from suitable sample
2. Isolation of halophilic bacteria from suitable sample
3. Enumeration of bacteria from compost sample
4. Isolation of hydrocarbon degrading microorganisms.
5. Study the effect of cellulolytic microorganisms on cotton fibres.
6. Estimation of soil Nitrogen by Kjeldahl method

## **References**

1. Environmental Microbiology – Ian L. Pepper, Charles P. Gerba & Terry J. Gentry – 3<sup>rd</sup> Edition – Academic Press.
2. Soil Microbiology – N. S. Subbarao – 4<sup>th</sup> Edition – Oxford & IBH Publishing Co.
3. Modern Soil Microbiology – Jan Dirk van Elsas, J. Trevor Trevors & Elaine M. H. Wellington – 2<sup>nd</sup> Edition – CRC Press.
4. Methods in Environmental Analysis: Water, Soil and Air – P. K. Gupta – 2<sup>nd</sup> Edition – Agrobios (India).
5. Experiments in Microbiology, Plant Pathology and Biotechnology – K. R. Aneja – 4<sup>th</sup> Edition – New Age International Publishers.
6. Practical Microbiology – R. C. Dubey & D. K. Maheshwari – 1<sup>st</sup> Edition – S. Chand & Company Ltd.

7. Manual of Environmental Microbiology – Christon J. Hurst – 4<sup>th</sup> Edition – ASM Press.
8. Principles and Applications of Soil Microbiology – David M. Sylvia, Jeffry J. Fuhrmann, Peter G. Hartel & David A. Zuberer – 2<sup>nd</sup> Edition – Pearson Education.
9. Laboratory Manual in Microbiology – P. Gunasekaran – 1<sup>st</sup> Edition – New Age International Publishers.
10. Bergey's Manual of Determinative Bacteriology – John G. Holt – 9<sup>th</sup> Edition – Williams & Wilkins.

# **MAJOR PRACTICAL COURSE V (b): BASIC TECHNIQUES IN BIOTECHNOLOGY**

**(Credit-2, Total Lectures- 60)**

## **Course Objectives**

The course is designed to:

1. To develop practical skills in isolation, estimation, and analysis of nucleic acids and proteins using standard molecular biology and biochemical techniques.
2. To understand principles and applications of microbial genetics, mutation induction, DNA amplification, and electrophoretic separation methods.
3. To gain hands-on experience in molecular techniques such as genomic DNA isolation, PCR, and PAGE for biological analysis.
4. To study biochemical methods for quantitative estimation of DNA and RNA and their significance in molecular and microbiological research.

## **Course Outcomes**

Upon completion of the course, students will be able to:

1. Isolate genomic DNA from bacterial cultures and perform quantitative estimation of DNA and RNA using biochemical methods.
2. Demonstrate mutation induction and selection of vitamin B12 requiring mutants of *Escherichia coli* using UV mutagenesis techniques.
3. Perform DNA amplification by PCR and understand its applications in molecular biology and microbial analysis.
4. Apply electrophoretic and molecular techniques such as PAGE and PCR for analysis of biomolecules and microbial genetics studies.

## **Practical Experiments**

1. Isolation of genomic DNA from bacterial culture
2. Isolation of Vitamin B12 requiring mutants of *E. coli* using UV induced mutation technique
3. Estimation of DNA by Diphenylamine method.
4. Estimation of RNA by Orcinol method
5. Demonstration of DNA amplification by PCR.
6. Electrophoresis of protein by PAGE.

## **References**

1. Molecular Cloning: A Laboratory Manual – Joseph Sambrook & David W. Russell – 3<sup>rd</sup> Edition – Cold Spring Harbor Laboratory Press.
2. Gene Cloning and DNA Analysis – T. A. Brown – 7<sup>th</sup> Edition – Wiley-Blackwell.
3. Practical Biotechnology – S. Janarthanan & S. Vincent – 1<sup>st</sup> Edition – Universities Press.
4. Principles and Techniques of Biochemistry and Molecular Biology – Keith Wilson & John Walker – 7<sup>th</sup> Edition – Cambridge University Press.

5. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
6. Textbook of Biotechnology – R. C. Dubey – 5<sup>th</sup> Edition – S. Chand & Company Ltd.
7. Laboratory Manual in Biochemistry – J. Jayaraman – 2<sup>nd</sup> Edition – New Age International Publishers.
8. Experiments in Microbiology, Plant Pathology and Biotechnology – K. R. Aneja – 4<sup>th</sup> Edition – New Age International Publishers.
9. Essential Molecular Biology: A Practical Approach – T. A. Brown – 1<sup>st</sup> Edition – Oxford University Press.
10. Biophysical Chemistry: Principles and Techniques – Avinash Upadhyay, Kakoli Upadhyay & Nirmalendu Nath – 4<sup>th</sup> Edition – Himalaya Publishing House.

# **MAJOR PRACTICAL COURSE I A (ELECTIVE): QUALITY ASSURANCE AND CONTROL IN INDUSTRIAL PRODUCTS (Credit-2, Total Lectures- 60)**

## **Course Objectives**

The course is designed to:

1. To develop skills in quantitative estimation and bioassay techniques used in pharmaceutical quality control as per Indian Pharmacopoeia.
2. To learn microbiological quality testing of pharmaceutical products including sterility testing, TAMC, and yeast & mould count.
3. To understand detection of specified microorganisms in pharmaceutical and related products.
4. To gain practical knowledge of pharmacopoeia testing procedures for ensuring product safety and quality compliance.

## **Course Outcomes**

Upon completion of the course, students will be able to:

1. Perform gravimetric and titrimetric estimations of pharmaceutical products.
2. Conduct sterility testing and microbial load analysis (TAMC and yeast & mould count).
3. Detect specified microorganisms such as *E. coli*, *S. aureus*, *P. aeruginosa*, *Candida albicans*, and *Salmonella* spp.
4. Apply pharmacopoeia guidelines to evaluate quality and safety of pharmaceutical products.

## **Practical Experiments**

1. Detection and enumeration of Total Aerobic Bacterial Count in a non-sterile pharmaceutical product
2. Detection and enumeration of Yeast and Mold in a non-sterile pharmaceutical product
3. Detection and enumeration of coliforms in pharmaceutical water sample
4. Detection and identification of specified objectionable microorganisms (*Staphylococcus aureus*/ *Pseudomonas aeruginosa*) in non-sterile pharmaceutical products
5. Estimation of alcohol from fermented broth (Gravimetric method)
6. Estimation of citric acid from fermented broth (Titrimetric method)
7. Sterility testing of injectable pharmaceutical product by direct inoculation method
8. Validation of Laminar Air Flow Cabinet

## **References**

1. Indian Pharmacopoeia – Government of India, Ministry of Health and Family Welfare – Latest Edition – Indian Pharmacopoeia Commission.



2. United States Pharmacopeia and National Formulary (USP–NF) – United States Pharmacopeial Convention – Latest Edition – USP Convention.
3. Pharmaceutical Microbiology – W. B. Hugo & A. D. Russell – 8<sup>th</sup> Edition – Blackwell Scientific Publications.
4. Pharmaceutical Microbiology – S. S. Purohit, Rajiv Rajan & Kakrani – 1<sup>st</sup> Edition – Agrobios (India).
5. Microbiological Quality Assurance in Pharmaceuticals, Cosmetics and Toiletries – Rosamund M. Baird, Norman A. Hodges & Stephen P. Denyer – 1<sup>st</sup> Edition – CRC Press.
6. Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials – World Health Organization – 2<sup>nd</sup> Edition – WHO Publications.
7. Good Manufacturing Practices for Pharmaceuticals – Sidney H. Willig & James R. Stoker – 5<sup>th</sup> Edition – Marcel Dekker Inc.
8. Manual of Industrial Microbiology and Biotechnology – Richard H. Baltz, Julian E. Davies & Arnold L. Demain – 3<sup>rd</sup> Edition – ASM Press.
9. Laboratory Manual in Microbiology – P. Gunasekaran – 1<sup>st</sup> Edition – New Age International Publishers.
10. Practical Pharmaceutical Microbiology – Wilfred Hugo & Stephen Denyer – 1<sup>st</sup> Edition – Blackwell Scientific Publications.

# **MAJOR PRACTICAL COURSE I B (ELECTIVE): MICROBIAL PRODUCTION OF METABOLITES AND BIOINSECTICIDES**

**(Credit-2, Total Lectures- 60)**

## **Course Objectives**

The course is designed to:

1. To provide practical training in bioassay techniques for determination and quantification of vitamins using microbial systems.
2. To develop skills in estimation of vitamins and plant growth regulators, particularly vitamin A and indole acetic acid (IAA).
3. To understand the effect of antibiotics on microbial growth through bioassay methods and antimicrobial evaluation.
4. To train students in preparation and production of beneficial microbial biopesticides used in sustainable agriculture.
5. To develop practical competence in isolation, cultivation, and production of industrially important microorganisms under laboratory conditions.

## **Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Perform bioassay techniques for estimation of vitamins and antibiotics, including vitamin B12 and bacitracin.
2. Estimate biologically important compounds, such as vitamin A and plant hormone IAA, using standard microbiological and biochemical methods.
3. Evaluate the effect of antimicrobial compounds on microbial growth through experimental analysis.
4. Prepare and produce microbial biopesticides, such as *Trichoderma* and *Bacillus*, for agricultural applications.
5. Demonstrate practical laboratory skills in microbial cultivation, production, and analysis, while following good laboratory practices.

## **Practical Experiments**

1. Bioassay of Vitamin B12
2. Estimation of Vitamin A
3. Production and estimation of IAA
4. Bioassay of Bacitracin
5. Production of biopesticides–*Trichoderma*
6. Production of biopesticides –*Bacillus*

## **References**

1. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.

2. Fermentation Technology – Stanbury, Whitaker & Hall – 3<sup>rd</sup> Edition – Elsevier Science.
3. Principles of Fermentation Technology – P. F. Stanbury & A. Whitaker – 2<sup>nd</sup> Edition – Pergamon Press.
4. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
5. Textbook of Biotechnology – R. C. Dubey – 5<sup>th</sup> Edition – S. Chand & Company Ltd.
6. Manual of Industrial Microbiology and Biotechnology – Richard H. Baltz, Julian E. Davies & Arnold L. Demain – 3<sup>rd</sup> Edition – ASM Press.
7. Pharmaceutical Microbiology – W. B. Hugo & A. D. Russell – 8<sup>th</sup> Edition – Blackwell Scientific Publications.
8. Biopesticides and Bioagents – Opendar Koul & G. S. Dhaliwal – 1<sup>st</sup> Edition – Taylor & Francis.
9. Experiments in Microbiology, Plant Pathology and Biotechnology – K. R. Aneja – 4<sup>th</sup> Edition – New Age International Publishers.
10. Practical Microbiology – R. C. Dubey & D. K. Maheshwari – 1<sup>st</sup> Edition – S. Chand & Company Ltd.

# **VOCATIONAL SKILL COURSE IN MICROBIOLOGY**

## **VSC II: FOOD TESTING AND QUALITY CONTROL- I**

**(Credit-2, Total Lectures- 60)**

### **Course Objectives**

1. To understand food quality standards, food safety regulations, and the role of regulatory agencies in maintaining food quality and consumer safety.
2. To learn analytical techniques for evaluation of physicochemical properties of food samples such as pH and titratable acidity.
3. To acquire practical knowledge of microbiological methods used for detection, isolation, and enumeration of microorganisms in foods.
4. To develop skills for detection and evaluation of traditional and chemical preservatives used in food products.

### **Course Outcomes**

After successful completion of the course, the students will be able to:

1. Explain the role of food regulatory agencies such as Food Safety and Standards Authority of India (FSSAI), AGMARK, and Bureau of Indian Standards (BIS) in food safety and quality assurance.
2. Perform physicochemical analysis of food samples including measurement of pH and determination of titratable acidity.
3. Isolate, enumerate, and detect microorganisms including coliform bacteria in food samples using standard microbiological techniques such as the MPN method.
4. Evaluate the effectiveness of traditional preservatives and detect commonly used chemical preservatives in market food products.

### **Practical Experiments**

- 1) Study of Food Quality Standards and Regulatory Agencies involved in Food Safety (FSSAI, AGMARK, BIS)
- 2) Measurement of pH of selected food samples (Fruit Juice/Dairy Products)
- 3) Determination of titratable acidity in selected food samples (Fruit Juice/Dairy Products)
- 4) Isolation and enumeration of bacteria in selected food samples
- 5) Detection of coliforms in food samples by MPN method
- 6) Evaluation of the efficacy of traditional food preservatives
  - a) Salt
  - b) Sugar
  - c) Vinegar
- 7) Detection of chemical preservatives in market foods (Jam/ Sauce/ Juice/ Mithai)
  - a) Benzoic acid / Sodium benzoate
  - b) Salicylic acid
  - c) Sulphites

## References

1. Food Microbiology – Frazier, W. C. & Westhoff, D. C. – 4<sup>th</sup> Edition – Tata McGraw-Hill Publishing Co., New Delhi.
2. Modern Food Microbiology – Jay, J. M., Loessner, M. J. & Golden, D. A. – 7<sup>th</sup> Edition – Springer, New York.
3. Laboratory Methods in Food and Dairy Microbiology – Harrigan, W. F. & McCance, M. E. – 8<sup>th</sup> Edition – Academic Press, London.
4. Food Microbiology – Adams, M. R. & Moss, M. O. – 3<sup>rd</sup> Edition – Royal Society of Chemistry, Cambridge.
5. Handbook of Analysis and Quality Control for Fruit and Vegetable Products – Ranganna, S. – 2<sup>nd</sup> Edition – Tata McGraw-Hill Publishing Co., New Delhi.
6. Food Safety and Standards Act, Rules and Regulations – Food Safety and Standards Authority of India (FSSAI) – Latest Edition – Government of India.
7. Compendium of Methods for the Microbiological Examination of Foods – American Public Health Association (APHA) – 5<sup>th</sup> Edition – APHA Press, USA.
8. Microbial Quality and Safety of Foods – R. Subhashini – 1<sup>st</sup> Edition – NPH India Publishers, India.

## Nature of the Practical Examination Question Paper and Distribution of Marks

### A) MAJOR PRACTICAL COURSE V (a)

| Question No.       | Nature/Type of Question                                                                                                                                                                                                                                                 | Marks     |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1                  | Isolation of cellulolytic bacteria from suitable sample <b>OR</b><br>Isolation of halophilic bacteria from suitable sample <b>OR</b><br>Enumeration of bacteria from compost sample <b>OR</b><br>Isolation of hydrocarbon degrading microorganisms from suitable sample | 20        |
| 2                  | Study the effect of cellulolytic microorganisms on cotton fibres<br><b>OR</b><br>Estimation of soil nitrogen by Kjeldahls method                                                                                                                                        | 15        |
| 3                  | Spotting / Viva                                                                                                                                                                                                                                                         | 10        |
| 4                  | Journal                                                                                                                                                                                                                                                                 | 05        |
| <b>Total Marks</b> |                                                                                                                                                                                                                                                                         | <b>50</b> |

### B) MAJOR PRACTICAL COURSE V (b)

| Question No.       | Nature/Type of Question                                                                                                                                          | Marks     |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1                  | Isolation of genomic DNA of given bacterial culture <b>OR</b><br>Isolation of Vitamin B12 requiring mutant of <i>E. coli</i> using UV induced mutation technique | 20        |
| 2                  | Estimation of DNA by Diphenylamine method <b>OR</b><br>Estimation of RNA by Orcinol method <b>OR</b><br>Electrophoresis of Protein by PAGE                       | 15        |
| 3                  | Spotting / Viva                                                                                                                                                  | 10        |
| 4                  | Journal                                                                                                                                                          | 05        |
| <b>Total Marks</b> |                                                                                                                                                                  | <b>50</b> |

**C) MAJOR PRACTICAL COURSE I A (ELECTIVE)**

| Question No.       | Nature/Type of Question                                                                                                                                                                                                                                                                                                                                                                                                                 | Marks     |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1                  | Detection and enumeration of Total Aerobic Bacterial Count in a non-sterile pharmaceutical product <b>OR</b><br>Detection and enumeration of Yeast and Mold in a non-sterile pharmaceutical product <b>OR</b><br>Detection and enumeration of coliforms in pharmaceutical water sample <b>OR</b><br>Detection and identification of <i>Staphylococcus aureus</i> / <i>Pseudomonas aeruginosa</i> in non-sterile pharmaceutical products | 20        |
| 2                  | Estimation of alcohol/citric acid from fermented broth <b>OR</b><br>Sterility testing of injectable pharmaceutical product by direct inoculation method <b>OR</b><br>Validation of Laminar air flow                                                                                                                                                                                                                                     | 15        |
| 3                  | Spotting/ Viva                                                                                                                                                                                                                                                                                                                                                                                                                          | 10        |
| 4                  | Journal                                                                                                                                                                                                                                                                                                                                                                                                                                 | 05        |
| <b>Total Marks</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>50</b> |

**D) MAJOR PRACTICAL COURSE I B (ELECTIVE)**

| Question No.       | Nature/Type of Question                                                                                                        | Marks     |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1                  | Bioassay of Vitamin B12/ Bacitracin <b>OR</b><br>Production of <i>Trichoderma</i> / <i>Bacillus thuringiensis</i> biopesticide | 20        |
| 2                  | Estimation of Vitamin A <b>OR</b><br>Estimation of IAA                                                                         | 15        |
| 3                  | Spotting/ Viva                                                                                                                 | 10        |
| 4                  | Journal                                                                                                                        | 05        |
| <b>Total Marks</b> |                                                                                                                                | <b>50</b> |

**E) VSC II: FOOD TESTING AND QUALITY CONTROL- I**

| <b>Question No.</b> | <b>Nature/Type of Question</b>                                                                                                                                                                           | <b>Marks</b> |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1                   | Isolation and enumeration of bacteria in selected food samples<br><b>OR</b><br>Detection of coliforms in food samples by MPN method<br><b>OR</b><br>Effect of Salt / Sugar / Vinegar on microbial growth | 20           |
| 2                   | Determination of titratable acidity in food samples<br><b>OR</b><br>Detection of Sodium benzoate / Salicylic acid / Sulphite in Market Foods                                                             | 15           |
| 3                   | Spotting / Viva                                                                                                                                                                                          | 10           |
| 4                   | Journal                                                                                                                                                                                                  | 05           |
|                     | <b>Total Marks</b>                                                                                                                                                                                       | <b>50</b>    |



**B. Sc. Part III**  
**Industrial Microbiology**  
**Semester VI**

# **MAJOR COURSE XI: ENVIRONMENTAL POLLUTION AND CONTROL**

**(Credit-2, Total Lectures- 30)**

## **Course Objectives**

The course is designed for:

1. Understanding the fundamental concepts and mechanisms of environmental pollution.
2. Learning environmental monitoring techniques, Environmental Monitoring System (EMS), and Environmental Impact Assessment (EIA).
3. Gaining knowledge of industrial activities responsible for waste generation.
4. Understanding characteristics and treatment methods of industrial wastewater and solid wastes.

## **Course Outcomes**

1. Upon successful completion of the course, students will be able to:
2. Explain concepts of environmental pollution, bioburden testing, EMS, and biosafety practices.
3. Describe Environmental Impact Assessment (EIA) and environmental monitoring procedures.
4. Discuss physical, chemical, and biological treatment methods used in wastewater management.
5. Analyze industrial waste characteristics and explain eutrophication and its control measures.

## **Unit I/ Credit I**

**Lectures - 15**

### **A) ENVIRONMENTAL MONITORING:**

- a. Bioburden Tests
- b. E.M.S. (Environmental Monitoring System): Concept & Process in dairy industry

### **B) BIOSAFETY and E.I.A.**

- a. E.I.A. (Environmental Impact Assessment): Concept & Process of assessment
- b. Biosafety in Laboratories and Pharmaceutical Industries.

## **Unit II/ Credit II**

**Lectures - 15**

### **A) CHARACTERISTICS OF WASTE WATER AS PER CPCB NORMS**

### **B) TREATMENT PROCEDURES:**

- a. Physical treatment – Sedimentation, screening and removal of oil and grease.

- b. Biological treatments - Septic tank, bio filter, activated sludge, extended aeration, oxidation ponds, anaerobic digestion-UASB (Up flow Anaerobic Sludge Blanket), Root zone technology
- c. Chemical treatment – Coagulation by alum / lime / polyelectrolyte /disinfection.

C) CHARACTERISTICS AND TREATMENT OF SOLID & LIQUID WASTES OF –

- a. Sugar Industry
- b. Dairy Industry

D) EUTROPHICATION -

- Classification of lakes, sources of nutrients, consequences, and control.

**References**

1. Environmental Pollution Control Engineering – C. S. Rao – 2<sup>nd</sup> Edition – New Age International Publishers.
2. Environmental Engineering – Howard S. Peavy, Donald R. Rowe & George Tchobanoglous – 1<sup>st</sup> Edition – McGraw-Hill Publications.
3. Wastewater Engineering: Treatment and Resource Recovery – Metcalf & Eddy – 5<sup>th</sup> Edition – McGraw-Hill Education.
4. Environmental Microbiology – Ian L. Pepper, Charles P. Gerba & Terry J. Gentry – 3<sup>rd</sup> Edition – Academic Press.
5. Methods in Environmental Analysis: Water, Soil and Air – P. K. Gupta – 2<sup>nd</sup> Edition – Agrobios (India).
6. Ecology, Environment and Pollution – S. S. Purohit & A. K. Saxena – 2<sup>nd</sup> Edition – Agrobios (India).
7. Environmental Chemistry – A. K. De – 7<sup>th</sup> Edition – New Age International Publishers.
8. Water Supply and Sanitary Engineering – G. S. Birdie & J. S. Birdie – 10<sup>th</sup> Edition – Dhanpat Rai Publishing Company.
9. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
10. Environmental Biotechnology – S. N. Jogdand – 1<sup>st</sup> Edition – Himalaya Publishing House.
11. Biosafety and Bioethics – P. K. Gupta – 1<sup>st</sup> Edition – Rastogi Publications.
12. Environmental Impact Assessment – Larry W. Canter – 2<sup>nd</sup> Edition – McGraw-Hill Publications.
13. Solid Waste Management – M. N. Rao & H. V. N. Rao – 1<sup>st</sup> Edition – CBS Publishers & Distributors.
14. Water Pollution – P. C. Trivedi & Raj Goel – 1<sup>st</sup> Edition – Akashdeep Publishing House.
15. Environmental Pollution Analysis – S. M. Khopkar – 2<sup>nd</sup> Edition – New Age International Publishers.

## **MAJOR COURSE XII: APPLICATIONS OF BIOTECHNOLOGY**

**(Credit-2, Total Lectures- 30)**

### **Course Objectives**

The course is designed for:

1. Understanding applications of genetic engineering in plants and animals.
2. Learning the role of genetic engineering in industry and environmental restoration.
3. Gaining knowledge of monoclonal antibody production and recombinant vaccines.
4. Understanding diagnostic applications of genetic engineering and recombinant DNA products.
- 5.

### **Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain applications of genetic engineering in agriculture, including transgenic plants and animals.
2. Describe the use of genetically engineered microorganisms (GEMs) in environmental and industrial applications.
3. Discuss production and applications of monoclonal antibodies, recombinant vaccines, and rDNA products.
4. Explain biotechnology-based diagnostic techniques such as ELISA, RIA, GeneXpert test, and Line Probe Assay.

### **Unit I/ Credit I**

**Lectures - 15**

#### **A) APPLICATIONS OF GENETIC ENGINEERING IN AGRICULTURE**

- a. Transgenic plants – concepts, methods for raising transgenic plants and applications.
- b. Transgenic animals – Concepts, methods for raising transgenic animals and applications.

#### **B) APPLICATIONS OF GENETIC ENGINEERING IN ENVIRONMENT**

- Bioremediation – Concept, Bioremediation Using GEMs

#### **C) APPLICATIONS OF GENETIC ENGINEERING IN INDUSTRY**

- GEMs in industry: Pharmaceutical and food industry

### **Unit II/ Credit II**

**Lectures - 15**

#### **A) MONOCLONAL ANTIBODIES AND RECOMBINANT VACCINES**

- a. Monoclonal antibodies - Definition, production- Hybridoma technology & applications
- b. Recombinant vaccines - Definition, recombinant vector vaccines & DNA vaccines.

#### **B) PRODUCTION OF rDNA PRODUCTS OF BIOTECHNOLOGY**

- a. rDNA Products: Insulin, Somatostatin and Interferons

b. Diagnostic techniques

1. Detection of human and plant pathogens- ELISA, RIA
2. TB detection: i) GeneXpert test ii) Line probe assay

**References**

1. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
2. Textbook of Biotechnology – R. C. Dubey – 5<sup>th</sup> Edition – S. Chand & Company Ltd.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA – Bernard R. Glick, Jack J. Pasternak & Cheryl L. Patten – 5<sup>th</sup> Edition – ASM Press.
4. Principles of Gene Manipulation and Genomics – Sandy B. Primrose & Richard Twyman – 7<sup>th</sup> Edition – Blackwell Publishing.
5. Introduction to Genetic Engineering – Desmond S. T. Nicholl – 3<sup>rd</sup> Edition – Cambridge University Press.
6. Biotechnology – U. Satyanarayana – 1<sup>st</sup> Edition – Books and Allied (P) Ltd.
7. Plant Biotechnology – Slater, Scott & Fowler – 2<sup>nd</sup> Edition – Oxford University Press.
8. Animal Biotechnology – M. M. Ranga – 2<sup>nd</sup> Edition – Agrobios (India).
9. Immunology – Kuby – 6<sup>th</sup> Edition – W. H. Freeman and Company.
10. Medical Biotechnology – S. N. Jogdand – 1<sup>st</sup> Edition – Himalaya Publishing House.
11. Environmental Biotechnology – S. N. Jogdand – 1<sup>st</sup> Edition – Himalaya Publishing House.
12. Diagnostic Microbiology – Bailey & Scott – 13<sup>th</sup> Edition – Mosby Elsevier.

**MAJOR COURSE II A (ELECTIVE):**  
**QUALITY CONTROL, STANDARDS AND REGULATORY**  
**FRAMEWORK IN AGRICULTURAL MICROBIOLOGY**  
**(Credit-2, Total Lectures- 30)**

**Course Objectives**

The course is designed for:

1. Understanding principles of quality control (QC) and quality assurance (QA) in agricultural microbial products.
2. Learning quality testing methods for biofertilizers, biopesticides, and bio stimulants including enumeration, purity, and shelf-life evaluation.
3. Gaining knowledge of national standards and regulatory requirements such as FCO specifications for microbial inoculants.
4. Understanding regulatory frameworks, labeling requirements, and intellectual property rights (IPR) related to agricultural microbiology products.

**Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain concepts of QA, QC, GLP, and GMP in production of agricultural microbial products.
2. Perform and interpret quality control tests including microbial enumeration, viability, purity, and contamination analysis.
3. Describe FCO standards and quality specifications for microbial inoculants such as *Rhizobium*, *Azotobacter*, *Azospirillum*, and phosphate-solubilizing bacteria.
4. Discuss regulatory requirements, labeling norms, and basic IPR concepts including patents, trademarks, and WTO-TRIPS provisions.

**Unit II/ Credit I**

**Lectures -15**

**A) FUNDAMENTALS OF QUALITY CONTROL AND QC TESTING**

- a) Concept of quality control (QC) and quality assurance (QA)
- b) Importance of QC in agricultural microbial products
- c) Types of agricultural microbial products:
  - a. Biofertilizers
  - b. Biopesticides
  - c. Bio stimulants – Plant growth-promoting rhizobacteria (PGPR) and Plant growth promoting fungi (PGPF)
- d) Sources of contamination in production
- e) Good Laboratory Practices (GLP)
- f) Good Manufacturing Practices (GMP)
- g) Documentation and record keeping

## B) QUALITY CONTROL TESTING OF AGRICULTURAL MICROBIAL PRODUCTS

- a) Microbial enumeration methods (CFU count)
- b) Viability testing of microbial inoculants
- c) Purity testing
- d) Contamination detection
- e) Shelf-life evaluation
- f) Carrier material quality testing
- g) Packaging quality assessment

## Unit II/Credit II

## Lectures – 15

### A) STANDARDS AND REGULATORY FRAMEWORK

- a) FCO standards for biofertilizers and biopesticides
- b) Quality specifications for:
  - i. *Rhizobium*
  - ii. *Azotobacter*
  - iii. *Azospirillum*
  - iv. Phosphate solubilizing bacteria
- c) Methods of labelling
- d) Basic concepts and laws relating to its infringement - Patent, Bio patent, Copyright, Trade secret, Trademark, Geographical Indications, Designs etc
- e) IPR and WTO, TRIPS
- f) Industries (Development and Regulation) Act 1951- object, licensing and registration

## References

1. Agricultural Microbiology – G. Rangaswami & D. J. Bagyaraj – 3<sup>rd</sup> Edition – PHI Learning Pvt. Ltd.
2. Biofertilizers in Agriculture and Forestry – N. S. Subbarao – 3<sup>rd</sup> Edition – Oxford & IBH Publishing Co.
3. Handbook of Biofertilizers and Biopesticides – H. D. Kumar – 1<sup>st</sup> Edition – Agrobios (India).
4. Principles and Applications of Soil Microbiology – David M. Sylvia, Jeffry J. Fuhrmann, Peter G. Hartel & David A. Zuberer – 2<sup>nd</sup> Edition – Pearson Education.
5. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
6. Quality Control in Microbiology – P. Gunasekaran – 1<sup>st</sup> Edition – New Age International Publishers.
7. Good Manufacturing Practices for Pharmaceuticals – Sidney H. Willig & James R. Stoker – 5<sup>th</sup> Edition – Marcel Dekker Inc.
8. Methods in Agricultural Microbiology – N. S. Subbarao – 2<sup>nd</sup> Edition – Oxford & IBH Publishing Co.
9. Manual of Soil, Plant and Water Analysis – P. K. Gupta – 2<sup>nd</sup> Edition – Agrobios (India).

10. Intellectual Property Rights – Deborah E. Bouchoux – 5<sup>th</sup> Edition – Cengage Learning.
11. Biotechnology and Intellectual Property Rights – N. S. Rathore & S. Chawla – 1<sup>st</sup> Edition – CBS Publishers & Distributors.
12. Fertilizer (Control) Order, 1985 – Government of India, Ministry of Agriculture – Latest Edition – Government Publication.



**MAJOR COURSE II B (ELECTIVE):**  
**MICROBIAL FERMENTATIONS, FOODS AND BIOFUELS**  
**(Credit-2, Total Lectures- 30)**

**Course Objectives**

The course is designed for:

1. Understanding microbial production of protein-rich biomass and single-cell protein using different substrates.
2. Learning mushroom cultivation, probiotic production, and their applications in food systems.
3. Understanding fermentation processes involved in production of Indian Made Foreign Liquors (IMFL).
4. Gaining knowledge of microbial production of vinegar, exopolysaccharides, and biofuels.

**Course Outcomes**

Upon successful completion of the course, students will be able to:

1. Explain microbial production of single-cell protein, mushrooms, and probiotics.
2. Describe fermentation processes used in production of alcoholic beverages and vinegar.
3. Discuss microbial synthesis and applications of exopolysaccharides such as xanthan and dextran.
4. Explain microbial production processes of biofuels including ethanol, biogas, and biodiesel.

**Unit I/ Credit I**

**Lectures -15**

A) PRODUCTION OF SPC- INTRODUCTION & PRODUCTION - ALGAE

B) PRODUCTION OF MUSHROOMS

- a. Introduction & types
- b. Spawn production
- c. Mushroom Production & harvesting

B) PROBIOTICS

- a. Introduction & common properties of probiotics
- b. Examples of probiotic microorganism
- c. Application of probiotics

C) MICROBIAL PRODUCTION OF INDIAN MADE FOREIGN LIQUORS- GIN, WHISKEY & RUM

- a. Introduction
- b. Production Process
- c. Quality of Product

**A) VINEGAR PRODUCTION**

- a. Introduction & Mechanism of vinegar production
- b. Production process: Orlean's process, trickling type generator and Submerged culture method
- c. Types & Uses of vinegar

**B) MICROBIAL PRODUCTION OF EXOPOLYSACCHARIDES**

- a. Introduction & Mechanism of synthesis
- b. Production process of Xanthan & Dextran gum
- c. Applications of xanthan and dextran gums

**C) PRODUCTION OF BIOFUELS**

- a. Ethanol- microorganisms used, fermentation conditions, recovery, purification of Ethanol
- b. Biogas- Biomass used, microbiology & Biochemistry of biogas production, models used and application of biogas
- c. Biodiesel production from Algae.

**References**

1. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
2. Principles of Fermentation Technology – P. F. Stanbury, A. Whitaker & S. J. Hall – 2<sup>nd</sup> Edition – Pergamon Press.
3. Fermentation Microbiology and Biotechnology – E. M. T. El-Mansi & C. F. A. Bryce – 3<sup>rd</sup> Edition – CRC Press.
4. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
5. Textbook of Biotechnology – R. C. Dubey – 5<sup>th</sup> Edition – S. Chand & Company Ltd.
6. Food Microbiology – William C. Frazier & Dennis C. Westhoff – 4<sup>th</sup> Edition – Tata McGraw-Hill.
7. Food Microbiology – James M. Jay – 6<sup>th</sup> Edition – Springer Publications.
8. Mushroom Cultivation – B. C. Suman & V. P. Sharma – 1<sup>st</sup> Edition – Daya Publishing House.
9. Probiotics and Prebiotics in Food, Nutrition and Health – V. K. Gupta & R. K. Sharma – 1<sup>st</sup> Edition – Springer Publications.
10. Alcoholic Beverages: Sensory Evaluation and Consumer Research – K. H. Bakker & Ronald J. Clarke – 1<sup>st</sup> Edition – Woodhead Publishing.
11. Handbook of Biofuels Production – Rafael Luque, Jacob C. Clark & James H. Clark – 2<sup>nd</sup> Edition – Woodhead Publishing.
12. Biofuels: Biotechnology, Chemistry and Sustainable Development – David Newton – 1<sup>st</sup> Edition – Facts on File Publications.

# **MAJOR PRACTICAL COURSE VI (a): ENVIRONMENTAL POLLUTION AND CONTROL**

**(Credit-2, Total Lectures- 60)**

## **Course Objectives**

The course is designed to:

1. To develop practical skills in physicochemical analysis of environmental samples such as industrial effluents, sewage, and potable water.
2. To understand the principles and significance of pollution indicators including BOD, COD, solids content, and organic load in environmental systems.
3. To gain hands-on experience in air, water, and wastewater quality monitoring using standard analytical methods.
4. To learn quantitative estimation techniques for assessing environmental pollution and evaluating treatment efficiency.

## **Course Outcomes**

Upon completion of the course, students will be able to:

1. Estimate biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of industrial effluents.
2. Analyze physical and chemical parameters of water and wastewater including TSS, TDS, TS, TVS, and fixed solids.
3. Determine organic matter, oil and grease content, and chlorine dosage in environmental and potable water samples.
4. Apply standard methods for air monitoring and environmental quality assessment of industrial and municipal waste systems.

## **Practical Experiments**

1. Determination of BOD of industrial effluents.
2. Determination of COD of industrial effluents.
3. Determination of organic matter from activated sludge of dairy industry
4. Air Monitoring by passive sampling method.
5. Determination of oil and grease from industrial waste.
6. Estimation of chlorine dose of potable water.
7. Estimation of TSS, TDS from sewage and industrial effluent.
8. Estimation of TS, TVS and fixed solids from sewage and industrial effluent.

## **References**

1. Standard Methods for the Examination of Water and Wastewater – American Public Health Association (APHA), American Water Works Association (AWWA) & Water Environment Federation (WEF) – 23<sup>rd</sup> Edition – APHA Publications.
2. Environmental Pollution Control Engineering – C. S. Rao – 2<sup>nd</sup> Edition – New Age International Publishers.
3. Wastewater Engineering: Treatment and Resource Recovery – Metcalf & Eddy – 5<sup>th</sup> Edition – McGraw-Hill Education.

4. Methods in Environmental Analysis: Water, Soil and Air – P. K. Gupta – 2<sup>nd</sup> Edition – Agrobios (India).
5. Environmental Microbiology – Ian L. Pepper, Charles P. Gerba & Terry J. Gentry – 3<sup>rd</sup> Edition – Academic Press.
6. Manual of Environmental Microbiology – Christon J. Hurst – 4<sup>th</sup> Edition – ASM Press.
7. Environmental Pollution Analysis – S. M. Khopkar – 2<sup>nd</sup> Edition – New Age International Publishers.
8. Water Pollution – P. C. Trivedi & Raj Goel – 1<sup>st</sup> Edition – Akashdeep Publishing House.
9. Laboratory Manual in Environmental Chemistry – S. K. Agarwal – 1<sup>st</sup> Edition – APH Publishing Corporation.

# **MAJOR PRACTICAL COURSE VI (b): APPLICATIONS OF BIOTECHNOLOGY**

**(Credit-2, Total Lectures- 60)**

## **Course Objectives**

The course is designed to:

1. To develop practical skills in immunological, molecular biology, and genetic engineering techniques used in microbiological research.
2. To understand principles and applications of antigen–antibody reactions, molecular diagnostics, and biomolecular separation techniques.
3. To gain hands-on experience in microbial cell manipulation, genetic transformation, and advanced biochemical analysis.
4. To familiarize students with analytical techniques such as electrophoresis, blotting methods, and immunoassays for biomolecule detection and characterization.

## **Course Outcomes**

Upon completion of the course, students will be able to:

1. Prepare biological products such as TAB vaccine and perform immunological assays like ELISA.
2. Demonstrate microbial cell manipulation techniques including protoplast preparation and fusion.
3. Perform molecular biology techniques such as genomic DNA separation using agarose gel electrophoresis and protein analysis by PAGE.
4. Apply advanced diagnostic techniques like Western blotting for detection and characterization of biomolecules.

## **Practical Experiments**

1. Preparation of TAB vaccine.
2. Demonstration of ELISA
3. Preparation of protoplast of bacterial cells.
4. Protoplast fusion of bacterial cells.
5. Separation and Visualization of genomic DNA by Agarose Gel Electrophoresis
6. Western Blotting Technique

## **References**

1. Molecular Cloning: A Laboratory Manual – Joseph Sambrook & David W. Russell – 3<sup>rd</sup> Edition – Cold Spring Harbor Laboratory Press.
2. Practical Biotechnology – S. Janarthanan & S. Vincent – 1<sup>st</sup> Edition – Universities Press.
3. Gene Cloning and DNA Analysis – T. A. Brown – 7<sup>th</sup> Edition – Wiley-Blackwell.
4. Principles and Techniques of Biochemistry and Molecular Biology – Keith Wilson & John Walker – 7<sup>th</sup> Edition – Cambridge University Press.
5. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
6. Laboratory Manual in Biochemistry – J. Jayaraman – 2<sup>nd</sup> Edition – New Age International Publishers.

7. Practical Immunology – Frank C. Hay & Olwyn M. R. Westwood – 4<sup>th</sup> Edition – Blackwell Science.
8. Experimental Biotechnology: Practical Manual Series – R. C. Dubey – 1<sup>st</sup> Edition – S. Chand & Company Ltd.
9. Essential Molecular Biology: A Practical Approach – T. A. Brown – 1<sup>st</sup> Edition – Oxford University Press.
10. Biophysical Chemistry: Principles and Techniques – Avinash Upadhyay, Kakoli Upadhyay & Nirmalendu Nath – 4<sup>th</sup> Edition – Himalaya Publishing House.

**MAJOR PRACTICAL COURSE II A (ELECTIVE):  
QUALITY CONTROL, STANDARDS AND REGULATORY  
FRAMEWORK IN AGRICULTURAL MICROBIOLOGY  
(Credit-2, Total Lectures- 60)**

**Course Objectives**

This course is designed for students to

1. Understand techniques to enumerate the bacteria in biofertilizers
2. Understand techniques for purity testing and contamination detection in biofertilizers.
3. Study the effect of storage conditions on viability and shelf life of biofertilizer microbes.
4. Evaluate nitrogen-fixing efficiency of biofertilizer organisms using analytical methods.

**Course Outcomes**

After completion of the course, students will be able to:

1. Perform enumeration of biofertilizer microorganisms such as *Rhizobium*, *Azotobacter*, and PSB using CFU methods.
2. Assess purity and detect microbial contamination using selective media.
3. Analyze the effect of storage conditions on microbial viability.
4. Estimate nitrogen-fixing ability of *Azotobacter* using the Kjeldahl method.

**Practical Experiments**

1. Quantitative estimation of target microbial population in Biofertilizers – *Rhizobium*/*Azotobacter*/*Azospirillum*/ PSB by CFU counting method
2. Evaluating the effect of improper storage conditions on CFU Count of target microbial population in biofertilizers (*Rhizobium*/*Azotobacter*/*Azospirillum*/PSB) – Recommended storage (cool and dark), high temperature (37-40°C) and Direct Sunlight.
3. Purity Testing of Biofertilizers – *Rhizobium*/*Azotobacter*/*Azospirillum*/PSB
4. Contamination detection in biofertilizers (*Rhizobium*/*Azotobacter*/*Azospirillum*/PSB) using Selective Media (Coliforms /Fungi)
5. Evaluation of nitrogen fixing ability of *Azotobacter* by using Kjeldahl method

**References**

1. Agricultural Microbiology – G. Rangaswami & D. J. Bagyaraj – 3<sup>rd</sup> Edition – PHI Learning Pvt. Ltd.
2. Biofertilizers in Agriculture and Forestry – N. S. Subbarao – 3<sup>rd</sup> Edition – Oxford & IBH Publishing Co.
3. Handbook of Biofertilizers and Biopesticides – H. D. Kumar – 1<sup>st</sup> Edition – Agrobios (India).

4. Methods in Agricultural Microbiology – N. S. Subbarao – 2<sup>nd</sup> Edition – Oxford & IBH Publishing Co.
5. Manual of Soil, Plant and Water Analysis – P. K. Gupta – 2<sup>nd</sup> Edition – Agrobios (India).
6. Practical Microbiology – R. C. Dubey & D. K. Maheshwari – 1<sup>st</sup> Edition – S. Chand & Company Ltd.
7. Experiments in Microbiology, Plant Pathology and Biotechnology – K. R. Aneja – 4<sup>th</sup> Edition – New Age International Publishers.
8. Principles and Applications of Soil Microbiology – David M. Sylvia, Jeffry J. Fuhrmann, Peter G. Hartel & David A. Zuberer – 2<sup>nd</sup> Edition – Pearson Education.
9. Laboratory Manual in Microbiology – P. Gunasekaran – 1<sup>st</sup> Edition – New Age International Publishers.
10. Bergey's Manual of Determinative Bacteriology – John G. Holt – 9<sup>th</sup> Edition – Williams & Wilkins.
11. Fertilizer (Control) Order, 1985 – Government of India, Ministry of Agriculture – Latest Edition – Government Publication.
12. Official Methods of Analysis – Association of Official Analytical Chemists (AOAC) – 21<sup>st</sup> Edition – AOAC International.



**MAJOR PRACTICAL COURSE II B (ELECTIVE):  
MICROBIAL FERMENTATIONS, FOODS AND BIOFUELS  
(Credit-2, Total Lectures- 60)**

**Course Objectives**

1. This course is designed for students to
2. Learn isolation and characteristics of lactic acid bacteria.
3. Understand estimation methods for alcohol and vinegar.
4. Gain knowledge of edible mushroom cultivation techniques.
5. Understand biogas production through anaerobic digestion.

**Course Outcomes**

After completion of the course, students will be able to:

1. Isolate and study lactic acid bacteria from fermented foods.
2. Estimate alcohol using standard analytical methods.
3. Perform vinegar production using fermentation techniques.
4. Cultivate edible mushrooms by bag culture method.
5. Demonstrate biogas production from organic waste.

**Practical Experiments**

1. Isolation of lactic acid bacteria from yoghurt
2. Production of alcohol from molasses and its estimation
3. Vinegar production by submerged culture method and its estimation
4. Cultivation of edible mushrooms by Bag culture method.
5. Production of Biogas from organic waste by anaerobic digestion (AD) Method.

**References**

1. Industrial Microbiology – Prescott & Dunn – 4<sup>th</sup> Edition – CBS Publishers & Distributors.
2. Principles of Fermentation Technology – P. F. Stanbury, A. Whitaker & S. J. Hall – 2<sup>nd</sup> Edition – Pergamon Press.
3. Food Microbiology – William C. Frazier & Dennis C. Westhoff – 4<sup>th</sup> Edition – Tata McGraw-Hill.
4. Food Microbiology – James M. Jay – 6<sup>th</sup> Edition – Springer Publications.
5. Mushroom Cultivation – B. C. Suman & V. P. Sharma – 1<sup>st</sup> Edition – Daya Publishing House.
6. Biotechnology: Fundamentals and Applications – S. S. Purohit – 6<sup>th</sup> Edition – Agrobios (India).
7. Handbook of Biofuels Production – Rafael Luque, Jacob C. Clark & James H. Clark – 2<sup>nd</sup> Edition – Woodhead Publishing.
8. Biogas Technology – D. Y. Goswami – 1<sup>st</sup> Edition – Prentice Hall India.
9. Practical Microbiology – R. C. Dubey & D. K. Maheshwari – 1<sup>st</sup> Edition – S. Chand & Company Ltd.

## **IKS 2: INDIAN KNOWLEDGE SYSTEM IN MICROBIOLOGY**

**(Major Specific)**

**(Credit-2, Total Lectures- 30)**

### **Course Objectives**

1. To introduce students to the fundamental concepts of Vedic Microbiology and the traditional understanding of microorganisms (*Sukshma Jivanu*) described in ancient Indian texts.
2. To examine indigenous methods of infection control, water purification, agriculture, and healthcare practices from a microbiological perspective.
3. To explore the principles and microbiological basis of traditional Indian fermentation systems and ethno-microbiological practices.
4. To develop an integrative understanding of Indian Knowledge Systems (IKS) and modern microbiology for promoting sustainable health, agriculture, and environmental practices.

### **Course Outcomes**

After successful completion of the course, students will be able to:

1. Explain references to microorganisms (*Krimis*) and disease prevention methods described in Vedic and classical texts, and relate them to modern microbiological concepts.
2. Analyze traditional practices such as Panchagavya, Jeevamrita, ancient water purification techniques, and medicinal plant usage in terms of their scientific and microbiological relevance.
3. Describe the microbial diversity and biochemical basis involved in traditional Indian fermented foods, beverages, and dairy products.
4. Evaluate the role of indigenous fermented foods and probiotics in nutrition, gut microbiome health, food safety, and sustainable living.

### **UNIT I: VEDIC MICROBIOLOGY AND TRADITIONAL PRACTICES Lectures – 15**

- 1) Introduction to Vedas and Vedic Microbiology
- 2) Contributions of key Vedic scholars: Sage Kanva, Agastya, Badarayani, Charak, Sushruta
- 3) *Sukshma jivanu* in Vedas- The forgotten part of Microbiology
- 4) Major groups of germs (*Krimis*) in Vedas
- 5) Controlling of germs (*Krimis*)
  - a) Prevention of infection
  - b) Precaution of Spread
  - c) Elimination of Pathogens- Destruction of microorganisms, Use of Sunrays
  - d) Eradication of Pathogens- Use of medicinal plants
- 6) Microbial diseases described during vedic period

- 7) Traditional agricultural practices and indigenous biofertilizers (Panchagavya, Dhanyagavya, Sasyagavya, and Jeevamrita): composition, impact on soil health, plant growth, and sustainable agriculture
- 8) Ancient water purification techniques: Use of Moringa seed extracts, Copper vessel, purification, and Sand filtration

## UNIT II: ETHNO-MICROBIOLOGY

Lectures – 15

- 1) Traditional food fermentation, preservation, and healthcare practices
- 2) Role of fermentation in nutrition, food safety, and preservation
- 3) Traditional fermentation versus modern microbial processes
- 4) Ethno-microbiology of Indian fermented foods:
  - a) Fermented rice–legume foods
  - b) Fermented soybean and non-soybean legume foods
  - c) Fermented vegetables and fruits
  - d) Fermented milk products
  - e) Fermented cereals
- 5) Traditional alcoholic beverages and their microbiological basis
- 6) Probiotics in Indian diets: Yogurt, Lassi, and Buttermilk
- 7) Role of fermented foods in gut microbiome diversity and health benefits

## References

1. Vedic Microbiology: A Scientific View. R. C. Dubey- Aastha Prakashan Banarasidass, 2020.
2. Vedic Microbiology – Gurus of Vedic Microbiology. C. F. Anjista and S. Kurup.
3. Microorganism in Vedas – R. K. Jakhmola.
4. *Sukshmjeevanu* in Vedas – The Forgotten Past of Microbiology in Indian Vedic Knowledge. Kuhad, U., Goel, G., Maurya, P.K., & Kuhad, R.C. *Indian Journal of Microbiology*, 61, 108 – 110 (2021). <https://doi.org/10.1007/s12088-020-00911-5>
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**VOCATIONAL SKILL COURSE IN MICROBIOLOGY**  
**VSC III: FOOD TESTING AND QUALITY CONTROL- II**  
**(Credit-2, Total Lectures- 60)**

**Course Objectives**

1. To understand microbiological and chemical methods used for detection of foodborne pathogens, contaminants, toxins, and adulterants in food samples.
2. To learn standard laboratory techniques for isolation and identification of bacterial and fungal contaminants associated with food spoilage and foodborne diseases.
3. To acquire practical knowledge of methods used for detection of aflatoxins and common adulterants present in food products.
4. To develop analytical and laboratory skills required for food quality assessment and food safety evaluation.

**Course Outcomes**

After successful completion of the course, the students will be able to:

1. Detect and identify common foodborne bacterial pathogens such as *Staphylococcus aureus* and *Escherichia coli* from food samples using microbiological techniques.
2. Isolate and identify fungal contaminants from food samples and evaluate their significance in food spoilage and food safety.
3. Detect aflatoxins in food samples using the BGYF (Bright Greenish Yellow Fluorescence) method and explain their importance in food safety.
4. Perform qualitative tests for detection of common adulterants in honey, ghee, butter, and paneer and interpret the results for assessment of food quality.

**Practical Experiments**

- 1) Detection of common foodborne bacterial pathogens from food samples (Minced Meat/Creamy Dessert/Street Food).
  - a) *Staphylococcus aureus*
  - b) *Escherichia coli*
- 2) Detection of fungal contaminants from given food samples (Bread/Onion)
- 3) Detection of Aflatoxins in food samples (Corn/Fig/Peanuts) using UV fluorescence (BGYF) method
- 4) Detection of common adulterants in Honey
  - a) Water Test (for Sugar syrup / Glucose)
  - b) Flame Test (for Moisture / Sugar syrup)
  - c) Iodine Test (for Starch)
- 5) Detection of common adulterants in Ghee / Butter
  - a) Iodine Test (for Starch)
  - b) Baudouin Test (for Vanaspati / Sesame oil)
  - c) Nitric Acid Test (for Vegetable oils)

- 6) Detection of common adulterants in Paneer
- a) Iodine Test (for Starch)
  - b) Hot Water Test (for Detergents / Synthetic milk)
  - c) Acid Test (for Excess acid / Baking powder)

## References

1. Food Adulteration and Food Safety – B. Srilakshmi, New Age International Publishers, New Delhi.
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4. Handbook of Food Analysis – S. S. Nielsen, Springer, New York.
5. Official Methods of Analysis – Association of Official Analytical Chemists (AOAC), AOAC International, Washington, DC.
6. Manual of Methods of Analysis of Foods – Food Safety and Standards Authority of India (FSSAI), Ministry of Health and Family Welfare, Government of India.
7. Food Safety and Quality Assurance – S. M. Reddy & M. S. Reddy, CBS Publishers, New Delhi.

## **SKILL ENHANCEMENT COURSE IN MICROBIOLOGY**

### **SEC III: Microbial Quality Assurance in Pharmaceutical Industries**

**(Credit-2, Total Lectures- 60)**

#### **Course Objectives**

1. To understand the principles and practices of microbiological quality control in pharmaceutical industries.
2. To learn methods for preparation, sterilization, quality testing, and sterility assessment of culture media and pharmaceutical products.
3. To acquire practical knowledge of environmental, personnel, and pharmaceutical water monitoring techniques used in pharmaceutical microbiology.
4. To develop laboratory skills for microbial enumeration, contamination detection, and sterility testing of sterile and non-sterile pharmaceutical products.

#### **Course Outcomes**

After successful completion of the course, the students will be able to:

1. Prepare and sterilize culture media and perform quality testing using growth promotion tests (GPT) and sterility assessment methods.
2. Conduct environmental and personnel monitoring using settle plate, swab, and finger dab methods for assessment of microbial contamination.
3. Perform microbiological testing of pharmaceutical water systems and determine Total Aerobic Microbial Count (TAMC) in potable water, purified water, and water for injection (WFI).
4. Carry out sterility testing, Gram staining, and microbial enumeration of sterile and non-sterile pharmaceutical products for quality control evaluation.

#### **Practical Experiments**

- 1) Preparation of culture media, sterilization and quality testing using growth promotion test (GPT) and pre-incubation sterility assessment.
- 2) Environmental & Personnel Monitoring
  - a) Microbial monitoring of air (by Settle plate method)
  - b) Surface monitoring (by Swab method)
  - c) Personnel monitoring (by Finger dab method)
- 3) Microbiological testing of pharmaceutical water systems using Total Aerobic Microbial Count (TAMC) method
  - a) Potable water (Raw feed)
  - b) Purified water (PW)
  - c) Water for injection (WFI)
- 4) Sterility testing of injectable pharmaceutical products by direct inoculation method.
- 5) Detection of contaminants in sterile pharmaceutical products by Gram staining.
- 6) Total Aerobic Microbial Count (TAMC) of non-sterile pharmaceutical products (Tablet/Syrup).

## References

1. Handbook of Microbiological Media – Atlas, R.M., CRC Press, Boca Raton, 2010.
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6. Pharmaceutical Microbiology – Jusko, W.J., John Wiley & Sons, New York, 2017.
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8. Practical Microbiology – Plummer, D.T., CBS Publishers, New Delhi, 2005.
9. Standard Operating Procedures: Care and Maintenance of Laboratory Equipment – AMREF Publisher, Nairobi, 2008, ISBN 978-9966874948.
10. Writing High-Quality Standard Operating Procedures: A Practical Guide – Johnson, M., Wiley, New York, 2016.

## Nature of the Practical Examination Question Paper and Distribution of Marks

### A) MAJOR PRACTICAL COURSE VI (a)

| Question No. | Nature/Type of Question                                                                                                                                                                            | Marks     |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1            | Determination of BOD/COD of a given sample <b>OR</b><br>Determination of organic matter from activated sludge of dairy industry <b>OR</b><br>Determination of oil and grease from industrial waste | 20        |
| 2            | Estimation of TSS/TDS/TS/TVS from sewage or industrial effluent <b>OR</b><br>Air monitoring by passive method <b>OR</b><br>Estimation of chlorine dose of potable water                            | 15        |
| 3            | Spotting / Viva                                                                                                                                                                                    | 10        |
| 4            | Journal                                                                                                                                                                                            | 05        |
|              | <b>Total Marks</b>                                                                                                                                                                                 | <b>50</b> |

### B) MAJOR PRACTICAL COURSE VI (b)

| Question No. | Nature/Type of Question                                                                                                                                                                 | Marks     |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1            | Preparation of protoplast of bacterial cells <b>OR</b><br>Protoplast fusion of bacterial cells. <b>OR</b><br>Separation and Visualization of genomic DNA by Agarose Gel Electrophoresis | 20        |
| 2            | Preparation of TAB vaccine. <b>OR</b><br>Western Blotting Technique                                                                                                                     | 15        |
| 3            | Spotting / Viva                                                                                                                                                                         | 10        |
| 4            | Journal                                                                                                                                                                                 | 05        |
|              | <b>Total Marks</b>                                                                                                                                                                      | <b>50</b> |



**C) MAJOR PRACTICAL COURSE II A (ELECTIVE)**

| Question No. | Nature/Type of Question                                                                                                                                                                                                                                                                                                                                      | Marks |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1            | Quantitative Estimation of <i>Rhizobium</i> / <i>Azotobacter</i> / <i>Azospirillum</i> / PSB population in a given biofertilizer sample by CFU counting method <b>OR</b><br>Evaluating the effect of improper storage conditions on CFU count of <i>Rhizobium</i> / <i>Azotobacter</i> / <i>Azospirillum</i> /PSB population in a given biofertilizer sample | 20    |
| 2            | Purity Testing of a given biofertilizer sample <b>OR</b><br>Contamination detection in a given biofertilizer sample using selective media (Coliforms /Fungi) <b>OR</b><br>Evaluating the nitrogen fixing ability of <i>Azotobacter</i> by using Kjeldahl method                                                                                              | 15    |
| 3            | Spotting/ Viva                                                                                                                                                                                                                                                                                                                                               | 10    |
| 4            | Journal                                                                                                                                                                                                                                                                                                                                                      | 05    |
| Total Marks  |                                                                                                                                                                                                                                                                                                                                                              | 50    |

**D) MAJOR PRACTICAL COURSE II B (ELECTIVE)**

| Question No. | Nature/Type of Question                                                                                                                                                                                  | Marks |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1            | Isolation of Lactic acid bacteria from yoghurt <b>OR</b><br>Cultivation of edible mushroom by Bag Culture Method <b>OR</b><br>Production of biogas from organic waste by anaerobic digestion (AD) Method | 20    |
| 2            | Estimation of vinegar/alcohol from fermented broth                                                                                                                                                       | 15    |
| 3            | Spotting/ Viva                                                                                                                                                                                           | 10    |
| 4            | Journal                                                                                                                                                                                                  | 05    |
| Total Marks  |                                                                                                                                                                                                          | 50    |

**E) VSC III: FOOD TESTING AND QUALITY CONTROL- II**

| Question No. | Nature / Type of Question                                                                                                                                         | Marks     |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1            | Detection of <i>Staphylococcus aureus</i> / <i>E. coli</i> from given food samples <b>OR</b><br>Detection of fungal contaminants from given food samples          | 20        |
| 2            | Detection of Aflatoxins in food samples (Corn / Fig / Peanuts) using UV fluorescence method <b>OR</b><br>Detection of Common Adulterants in Honey / Ghee / Paneer | 15        |
| 3            | Spotting / Viva                                                                                                                                                   | 10        |
| 4            | Journal                                                                                                                                                           | 05        |
|              | <b>Total Marks</b>                                                                                                                                                | <b>50</b> |

**F) SEC III: MICROBIAL QUALITY ASSURANCE IN PHARMACEUTICAL INDUSTRIES**

| Question No. | Nature / Type of Question                                                                                                                                                                                                                                                                                 | Marks     |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1            | Total Aerobic Microbial Count (TAMC) of Potable water / Purified water / Water for injection / Tablet /Syrup                                                                                                                                                                                              | 20        |
| 2            | Microbial monitoring of air (by Settle plate method) / Surface monitoring (by Swab method) / Personnel monitoring (by Finger dab method) <b>OR</b><br>Sterility testing of injectable pharmaceutical products <b>OR</b><br>Detection of contaminants in sterile pharmaceutical products by Gram staining. | 15        |
| 3            | Viva/ Spotting                                                                                                                                                                                                                                                                                            | 10        |
| 4            | Journal                                                                                                                                                                                                                                                                                                   | 05        |
|              | <b>Total Marks</b>                                                                                                                                                                                                                                                                                        | <b>50</b> |

# **SHIVAJI UNIVERSITY, KOLHAPUR**



**Established: 1962**

**A<sup>++</sup> Accredited by NAAC (2021) with CGPA 3.52**

## **NEW SYLLABUS FOR OPEN ELECTIVE COURSE IN INDUSTRIAL MICROBIOLOGY**

**B. A. Part III / B. Com. Part III**

**Semester V**

**Structure and Syllabus in Accordance with  
National Education Policy - 2020 (NEP 2.0)  
with Multiple Entry and Multiple Exit**

**(To be implemented from Academic Year 2026-27)**

## **OE 5: INTRODUCTION TO SOIL SCIENCE AND SOIL MICROBIOLOGY**

**(Credit-2, Total Lectures- 60)**

### **Course Objectives**

1. To introduce students to soil as an important natural resource and its role in the environment.
2. To develop basic understanding of soil properties through simple observation and demonstration.
3. To create awareness about soil organic matter and soil microorganisms in maintaining soil fertility.
4. To help students relate soil characteristics to agriculture, plant growth, and sustainable practices.

### **Course Outcomes**

After successful completion of the course, students will be able to:

1. Collect and prepare soil samples and identify different soil types based on colour and texture.
2. Demonstrate basic soil properties such as pH, moisture content, and water holding capacity.
3. Explain the importance of organic matter and microorganisms in soil health.
4. Describe the role of root nodules of leguminous plants in improving soil fertility and sustainability.

### **Practical Experiments**

- 1) Collection and preparation of soil samples from different locations
- 2) Study of soil colour
- 3) Study of different soil types
- 4) Determination of soil texture
- 5) Determination of soil pH
- 6) Determination of soil moisture content
- 7) Study of water holding capacity of soil
- 8) Observation of presence of organic matter in soil by hydrogen peroxide
- 9) Observation of presence of microorganisms in soil
- 10) Collection of root nodules of leguminous plants and study their importance

### **References**

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2. D.K. Maheshwari – Soil Microbiology – I.K. International, 2021.
3. G. Rangaswami & D.J. Bagyaraj – Agricultural Microbiology – PHI Learning, 2004.
4. P.C. Jaiswal – Soil, Plant and Water Analysis – New Age International, 2010.

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8. F.R. Troeh, J.A. Hobbs & R.L. Donahue – Soils and Soil Fertility, 6<sup>th</sup> Edition – Blackwell Publishing, 2004.
9. M.M. Rai – Principles of Soil Science – New Age International, 2008.
10. Purohit & Singh – Soil Microbiology – Agrobios India, 2010.

## OE 5: मृदाविज्ञान व मृदा सूक्ष्मजीवशास्त्राची ओळख

(क्रेडिट्स: 02 एकूण तास: 60)

### अभ्यासक्रमाची उद्दिष्टे (Course Objectives)

1. मृदा ही एक महत्त्वाची नैसर्गिक संपत्ती आहे याची विद्यार्थ्यांना ओळख करून देणे.
2. निरीक्षण व सोप्या प्रात्यक्षिकांच्या माध्यमातून मृदेचे मूलभूत गुणधर्म समजावून देणे.
3. मृदेतील सेंद्रिय पदार्थ व सूक्ष्मजीवांची मृदेची सुपीकता टिकवून ठेवण्यात असलेली भूमिका स्पष्ट करणे.
4. शेती, वनस्पती वाढ व शाश्वत पद्धतींशी मृदेचे संबंध विद्यार्थ्यांना समजावून देणे.

### अभ्यासक्रमाचे परिणाम (Course Outcomes)

अभ्यासक्रम यशस्वीरीत्या पूर्ण केल्यानंतर विद्यार्थी:

1. मृदेचे नमुने गोळा करून त्यांची तयारी करू शकतील तसेच रंग व पोताच्या आधारे मृदेचे प्रकार ओळखू शकतील.
2. pH, आर्द्रता व जलधारण क्षमता यांसारख्या मृदेच्या मूलभूत गुणधर्मांचे प्रात्यक्षिक सादर करू शकतील.
3. मृदेच्या आरोग्यात सेंद्रिय पदार्थ व सूक्ष्मजीवांचे महत्त्व स्पष्ट करू शकतील.
4. मृदेची सुपीकता व शाश्वत शेतीमध्ये शेंगपिकांच्या मुळांवरील गाठींची भूमिका वर्णन करू शकतील.

### प्रात्यक्षिक अभ्यासक्रम (Practical Syllabus)

- 1) विविध ठिकाणांहून मृदेचे नमुने गोळा करणे व त्यांची तयारी करणे
- 2) मृदेच्या रंगाचा अभ्यास करणे
- 3) मृदेचे विविध प्रकार अभ्यासणे
- 4) मृदेच्या पोताचे निर्धारण करणे
- 5) मृदेच्या pH चे निर्धारण करणे
- 6) मृदेतील आर्द्रतेचे प्रमाण निश्चित करणे
- 7) मृदेच्या जलधारण क्षमतेचा अभ्यास करणे
- 8) हायड्रोजन पेरोक्साइडच्या सहाय्याने मृदेतील सेंद्रिय पदार्थांच्या उपस्थितीचे निरीक्षण करणे
- 9) मृदेतील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे
- 10) शेंगपिकांच्या मुळांवरील गाठींचे संकलन व त्यांच्या महत्त्वाचा अभ्यास करणे

## Nature of the Practical Examination Question Paper and Distribution of Marks

### OE 5: INTRODUCTION TO SOIL SCIENCE AND SOIL MICROBIOLOGY

| Question No. | Nature/Type of Question                                                                                                               | Marks     |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1            | Determination of soil texture <b>OR</b><br>Determination of soil pH <b>OR</b><br>Determination of soil moisture content               | 20        |
| 2            | Observation of presence of organic matter in soil by hydrogen peroxide <b>OR</b><br>Observation of presence of microorganisms in soil | 15        |
| 3            | Viva                                                                                                                                  | 10        |
| 4            | Journal                                                                                                                               | 05        |
|              | <b>Total Marks</b>                                                                                                                    | <b>50</b> |

### OE 5: मृदाविज्ञान व मृदा सूक्ष्मजीवशास्त्राची ओळख

| प्रश्न क्र. | प्रश्नाचा प्रकार                                                                                                                                        | गुण       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1           | मृदेच्या पोताचे निर्धारण करणे किंवा<br>मृदेच्या pH चे निर्धारण करणे किंवा<br>मृदेतील आर्द्रतेचे प्रमाण निश्चित करणे                                     | 20        |
| 2           | हायड्रोजन पेरोक्साइडच्या सहाय्याने मृदेतील सेंद्रिय पदार्थांच्या<br>उपस्थितीचे निरीक्षण करणे किंवा<br>मृदेतील सूक्ष्मजीवांच्या उपस्थितीचे निरीक्षण करणे | 15        |
| 3           | तोंडी परीक्षा                                                                                                                                           | 10        |
| 4           | जर्नल                                                                                                                                                   | 05        |
|             | <b>एकूण गुण</b>                                                                                                                                         | <b>50</b> |