



**BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI-620024**  
**B.SC. ENVIRONMENTAL SCIENCE**

**CHOICE BASED CREDIT SYSTEM–LEARNING OUTCOMES BASED CURRICULUM  
 FRAME WORK (CBCS - LOCF)**

(Applicable to the candidates admitted from the academic year 2026-2027 onwards)

| Sem | Part  | Courses                                     | Title                                     | Ins. Hrs. | Credits | Exam. Hours | Maximum Marks |      |       |
|-----|-------|---------------------------------------------|-------------------------------------------|-----------|---------|-------------|---------------|------|-------|
|     |       |                                             |                                           |           |         |             | Int.          | Ext. | Total |
| I   | I     | Ability Enhancement Course – I (AEC - I)    | (Tamil\$ / Other Languages+, #)           | 6         | 3       | 3           | 30            | 70   | 100   |
|     | II    | Ability Enhancement Course –II (AEC - II)   | English Course - I                        | 6         | 3       | 3           | 30            | 70   | 100   |
|     | III   | Core Course -1 (CC - 1)                     | Fundamentals of Environmental Science     | 4         | 4       | 3           | 30            | 70   | 100   |
|     |       | Core Practical - 1 (CP - 1)                 | Environmental Science Lab                 | 4         | 4       | 3           | 40            | 60   | 100   |
|     |       | Allied Course - 1 (AC - 1)                  | Any one from the list                     | 4         | 4       | 3           | 30            | 70   | 100   |
|     |       | Allied Course Practical - 1 (ACP-1)         | Any one from the list                     | 2         | **      | **          | **            | **   | **    |
|     | IV    | Value Education                             |                                           | 2         | 2       | 3           | 30            | 70   | 100   |
|     |       | Interdisciplinary Course - 1 (IDC - 1) #    | One Course from Outside Department        | 2         | 2       | 3           | 30            | 70   | 100   |
|     | Total |                                             |                                           |           | 30      | 22          | --            | --   | --    |
| II  | I     | Ability Enhancement Course –III (AEC - III) | (Tamil\$ / Other Languages+, #)           | 6         | 3       | 3           | 30            | 70   | 100   |
|     | II    | Ability Enhancement Course –IV (AEC - IV)   | English Course - II                       | 6         | 3       | 3           | 30            | 70   | 100   |
|     | III   | Core Course- 2 (CC - 2)                     | Concepts of Ecology                       | 4         | 4       | 3           | 30            | 70   | 100   |
|     |       | Core Practical - 2 (CP - 2)                 | Ecology Lab                               | 4         | 4       | 3           | 40            | 60   | 100   |
|     |       | Allied Course - 2 (AC - 2)                  | Any one from the list                     | 2         | 4       | 3           | 30            | 70   | 100   |
|     |       | Allied Course Practical – 1 (ACP-I)         | Any one from the list                     | 4         | 4       | 3           | 40            | 60   | 100   |
|     | IV    | Skill Enhancement Course - 1 (SEC - 1) ##   | Naan Mudhalvan Course/SEC (List enclosed) | 2         | 2       | 3           | 30            | 70   | 100   |
|     |       | Interdisciplinary Course – 2 (IDC - 2) #    | One Course from Outside Department        | 2         | 2       | 3           | 30            | 70   | 100   |
|     | Total |                                             |                                           |           | 30      | 26          | --            | --   | --    |

|     |                                                                                  |                                                |                                           |    |    |    |    |     |     |
|-----|----------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------|----|----|----|----|-----|-----|
| III | I                                                                                | Ability Enhancement Course – V (AEC - V)       | (Tamil\$ / Other Languages+, #)           | 6  | 3  | 3  | 30 | 70  | 100 |
|     | II                                                                               | Ability Enhancement Course - VI (AEC - VI)     | English Course - III                      | 6  | 3  | 3  | 30 | 70  | 100 |
|     | III                                                                              | Core Course- 3(CC - 3)                         | Natural Resources and Biodiversity        | 4  | 4  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Core Practical - 3 (CP - 3)                    | Biodiversity Lab                          | 4  | 4  | 3  | 40 | 60  | 100 |
|     |                                                                                  | Allied Course - 3 (AC - 3)                     | Any one from the list                     | 4  | 4  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Allied Course Practical - 2 (ACP-2)            | Any one from the list                     | 2  | ** | ** | ** | **  | **  |
|     | IV                                                                               | Skill Enhancement Course - 2 (SEC - 2) ##      | Naan Mudhalvan Course/SEC (List enclosed) | 2  | 2  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Interdisciplinary Course - 3 (IDC - 3) \$\$    | One Course from Outside Department        | 2  | 2  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Health & Wellness @                            |                                           | -- | 1  | -- |    |     | 100 |
|     | Total                                                                            |                                                |                                           | 30 | 23 | -- | -- | --  | 800 |
| I   | Ability Enhancement Course - VII (AEC - VII)                                     | (Tamil\$ / Other Languages+, # )               | 6                                         | 3  | 3  | 30 | 70 | 100 |     |
| IV  | II                                                                               | Ability Enhancement Course - VIII (AEC - VIII) | English Course - IV                       | 6  | 3  | 3  | 30 | 70  | 100 |
|     | III                                                                              | Core Course - 4 (CC - 4)                       | Environmental Pollution                   | 4  | 4  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Core Practical - 4 (CP - 4)                    | Environmental Pollution Lab               | 4  | 4  | 3  | 40 | 60  | 100 |
|     |                                                                                  | Allied Course - 4 (AC - 4)                     | Any one from the list                     | 2  | 4  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Allied Course Practical - 2 (ACP-2)            | Any one from the list                     | 4  | 4  | 3  | 40 | 60  | 100 |
|     | IV                                                                               | Skill Enhancement Course - 3 (SEC - 3) ##      | Naan Mudhalvan Course/SEC (List enclosed) | 2  | 2  | 3  | 30 | 70  | 100 |
|     |                                                                                  | Interdisciplinary Course – 4 (IDC - 4) \$\$    | One Course from Outside Department        | 2  | 2  | 3  | 30 | 70  | 100 |
|     | Total                                                                            |                                                |                                           | 30 | 26 | -- | -- | --  | 800 |
|     | Summer Internship / Industrial Activity during the Summer Vacation after II Year |                                                |                                           |    |    |    |    |     |     |

|    |             |                                            |                                              |     |     |    |    |    |      |
|----|-------------|--------------------------------------------|----------------------------------------------|-----|-----|----|----|----|------|
| V  | III         | Core Course - 5 (CC - 5)                   | Environmental Microbiology                   | 4   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Course - 6 (CC - 6)                   | Biostatistics and Computation                | 5   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Course - 7 (CC - 7)                   | Environmental Tools and Techniques           | 5   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Course - 8 (CC - 8)                   | Environmental Law and Techniques             | 5   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Practical - 5 (CP - 5)                | Environmental Microbiology (P)               | 5   | 4   | 3  | 40 | 60 | 100  |
|    | IV          | Skill Enhancement Course - 4 (SEC - 4)     | Any one from the list                        | 2   | 2   | 3  | 30 | 70 | 100  |
|    |             | Skill Enhancement Course - 5 (SEC - 5) ##  | Naan Mudhalvan Course/SEC (List enclosed)    | 2   | 2   | 3  | 30 | 70 | 100  |
|    |             | Introduction to Disaster Management        |                                              | 2   | 2   | 3  | 30 | 70 | 100  |
|    |             | Summer Internship / Industrial Activity @@ | (with Viva-Voce)                             | --  | 2   | -- | 20 | 80 | 100  |
|    | Total       |                                            |                                              | 30  | 28  | -- | -- | -- | 900  |
| VI | III         | Core Course - 9 (CC - 9)                   | Environmental Toxicology                     | 4   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Course- 10 (CC - 10)                  | Climate Change and Sustainability            | 5   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Course- 11 (CC - 11)                  | Environmental Safety and Health Management   | 5   | 4   | 3  | 30 | 70 | 100  |
|    |             | Core Project Work (CPW) @@                 | Project Work (with Viva-Voce)                | 6   | 4   | 3  | 20 | 80 | 100  |
|    | IV          | Value Added Course                         | General Studies for Competitive Examinations | 2   | 1   | -- | 30 | 70 | 100  |
|    |             | Skill Enhancement Course - 6 (SEC - 6)     | Any one from the list                        | 2   | 2   | 3  | 30 | 70 | 100  |
|    |             | Skill Enhancement Course - 7 (SEC - 7) ##  | Naan Mudhalvan Course/SEC (List enclosed)    | 2   | 2   | 3  | 30 | 70 | 100  |
|    |             | Environmental Studies                      |                                              | 2   | 2   | 3  | 30 | 70 | 100  |
|    |             | Gender Studies                             |                                              | 2   | 1   | 3  | 30 | 70 | 100  |
|    |             | Extension Activities *                     |                                              | --  | 1   | -- | -- | -- | --   |
|    | Total       |                                            |                                              | 30  | 25  | -- | -- | -- | 900  |
|    | Grand Total |                                            |                                              | 180 | 150 | -- | -- | -- | 4900 |

### Allied Papers

#### First Year Students

Biology I - Theory  
Biology Laboratory - Practical  
Biology II - Theory

#### Second Year Students

Chemistry

| <b>SKILL ENHANCEMENT COURSE (SEC)</b> |                                  |                |                                          |
|---------------------------------------|----------------------------------|----------------|------------------------------------------|
| <b>Sl. No.</b>                        | <b>Title of paper</b>            | <b>Sl. No.</b> | <b>MANDATORY Naan Mudhalvan Scheme##</b> |
| 1.                                    | Vermicomposting                  | 1.             | <b>2<sup>nd</sup> Semester:</b>          |
| 2.                                    | Aquaponics                       |                |                                          |
| 3.                                    | Rainwater Harvesting             | 2.             | <b>3<sup>rd</sup> Semester:</b>          |
| 4.                                    | Carbon Budgeting                 |                |                                          |
| 5.                                    | Circular Economy                 | 3.             | <b>4<sup>th</sup> Semester:</b>          |
| 6.                                    | Eco-friendly Products            |                |                                          |
| 7.                                    | Intellectual Property Rights     | 4.             | <b>5<sup>th</sup> Semester:</b>          |
| 8.                                    | Environmental Quality Assessment |                |                                          |
| --                                    |                                  | 5.             | <b>6<sup>th</sup> Semester:</b>          |

| <b>INTERDISCIPLINARY COURSE (IDC)<br/>FOR WHO HAVE OPT TAMIL AS PART-I<br/>(for other Department Students only)</b> |                                            |
|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 1 <sup>st</sup> Semester                                                                                            | Environmental Education for Sustainability |
| 2 <sup>nd</sup> Semester                                                                                            | Environment and Health                     |
| 3 <sup>rd</sup> Semester                                                                                            | Green Auditing                             |
| 4 <sup>th</sup> Semester                                                                                            | Marine Pollution                           |

| <b>INTERDISCIPLINARY COURSE (IDC)#<br/>FOR WHO HAVE NOT OPT TAMIL AS PART - I</b>                                                                                                                   |                          |                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------|
| Those who have studied Tamil upto 10 <sup>th</sup> +2 but opt for other languages in degree                                                                                                         | 1 <sup>st</sup> Semester | Special Tamil - I  |
|                                                                                                                                                                                                     | 2 <sup>nd</sup> Semester | Special Tamil - II |
| Those who have not studied Tamil in school level                                                                                                                                                    | 1 <sup>st</sup> Semester | Basic Tamil - I    |
|                                                                                                                                                                                                     | 2 <sup>nd</sup> Semester | Basic Tamil - II   |
| Those students who opt for either special Tamil (or) Basic Tamil as IDCs, have to choose 2 more IDCs courses in their 3 <sup>rd</sup> and 4 <sup>th</sup> Semester from Outside his/her department. |                          |                    |

| <b>INTERDISCIPLINARY COURSE (IDC) \$\$<br/>FOR NCC CADETS ONLY</b>                                                                                                        |                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| <b>NCC Course is a Compulsory Course for the NCC Cadets in the 3<sup>rd</sup> Semester:</b>                                                                               | <b>NCC Course is a Compulsory Course for the NCC Cadets in the 4<sup>th</sup> Semester:</b>                |
| Introduction to NCC                                                                                                                                                       | 1. Special Subject Army <b>(or)</b><br>2. Special Subject Navy <b>(or)</b><br>3. Special Subject Air force |
| Those students who opt for NCC Courses as IDCs, have to choose 2 more IDCs courses in their 1 <sup>st</sup> and 2 <sup>nd</sup> Semester from Outside his/her department. |                                                                                                            |

## SUMMARY OF CURRICULUM STRUCTURE OF UG PROGRAMMES

| Sl. No.      | Part | Types of the Courses                                                                          | No. of Courses | Credits for each Course | Total Credits | Marks       |
|--------------|------|-----------------------------------------------------------------------------------------------|----------------|-------------------------|---------------|-------------|
| 1.           | I    | Ability Enhancement Course                                                                    | 4              | 3                       | 12            | 400         |
| 2.           | II   | Ability Enhancement Course                                                                    | 4              | 3                       | 12            | 400         |
| 3.           | III  | Core Course                                                                                   | 11             | 4                       | 44            | 1100        |
| 4.           |      | Core Practical                                                                                | 5              | 4                       | 20            | 500         |
| 5.           |      | Allied Course (AC)                                                                            | 4              | 4                       | 16            | 400         |
| 6.           |      | Allied Course Practical (ACP)                                                                 | 2              | 4                       | 8             | 200         |
| 7.           |      | Core Project Work (CPW)                                                                       | 1              | 4                       | 4             | 100         |
| 8.           | IV   | Skill Enhancement Course (SEC)                                                                | 7              | 2                       | 14            | 700         |
| 9.           |      | Interdisciplinary Course (IDC)                                                                | 4              | 2                       | 8             | 400         |
| 10.          |      | Value Education                                                                               | 1              | 2                       | 2             | 100         |
| 11.          |      | Health and Wellness                                                                           | 1              | 1                       | 1             | 100         |
| 12.          |      | Introduction to Disaster Management                                                           | 1              | 2                       | 2             | 100         |
| 13.          |      | Summer Internship / Industrial Activity                                                       | 1              | 2                       | 2             | 100         |
| 14.          |      | Value Added Course                                                                            | 1              | 1                       | 1             | 100         |
| 15.          |      | Environmental Studies                                                                         | 1              | 2                       | 2             | 100         |
| 16.          |      | Gender Studies                                                                                | 1              | 1                       | 1             | 100         |
| 17.          |      | <b>EXTENSION ACTIVITIES</b> (NCC / NSS / SPORTS / ANTI DRUG CELL / YRC & Any Other Activities | --             | 1                       | 1             | --          |
| <b>Total</b> |      |                                                                                               | <b>49</b>      | <b>-</b>                | <b>150</b>    | <b>4900</b> |

\$ For those who have studied Tamil upto 10<sup>th</sup>+2 (Regular Stream)

+ Syllabus for other Languages should be on par with Tamil at degree level

# Those who have studied Tamil upto 10<sup>th</sup>+2 but opt for other languages in degree level under Part –I should study special Tamil and those who have not studied Tamil in the school level should study Basic Tamil in Part– IV under the Interdisciplinary Course.

\*\* Examination at the end of the next semester

# Naan Mudhalvan Scheme: As per the Naan Mudhalvan Scheme instructions, 5 courses from 2nd to 6th semester should be studied under Skill Enhancement Course.

\$ NCC Course is one of the Choices in the Interdisciplinary Course. Only the NCC Cadets are eligible to choose this

\$ course. However, NCC Course is a Compulsory Course for the NCC Cadets.

@ **Health and Wellness: Assessments:**

- Use self-reflective worksheets to assess their understanding
- submit the worksheets to internal audit / external audit
- Every student's activity report should be documented and the same have to be assessed by the Physical Director with Mentor. The evaluation should be for 100 marks. No examination is required.

**Scheme of Evaluation:**

| <b>Part</b>  | <b>Description</b>                       | <b>Marks</b> |
|--------------|------------------------------------------|--------------|
| A            | Report                                   | 40           |
| B            | Attendance                               | 20           |
| C            | Activities (Observation During Practice) | 40           |
| <b>Total</b> |                                          | <b>100</b>   |

@ **Summer Internship / Industrial Activity**

@

Internship will be carried out during the summer vacation after the second year. Viva-Voce will be conducted by the college and Marks shall be sent to the University and the same will be included in the 5<sup>th</sup> semester Mark Statement.

**Summer Internship / Industrial Activity& Project Work**

**Scheme of Evaluation:**

| <b>Description</b> | <b>Marks</b> |
|--------------------|--------------|
| Report             | 80           |
| Viva-Voce          | 20           |
| <b>Total</b>       | <b>100</b>   |

\* Extension Activities shall be outside instruction hours.

## PROGRAMME OBJECTIVES

1. Build foundational and advanced knowledge in environmental science and sustainability.
2. Develop scientific inquiry, analytical reasoning, and research aptitude.
3. Enhance practical, technical, and employability skills through laboratory and field training.
4. Promote environmental ethics, leadership, and community engagement.
5. Prepare graduates for higher education, entrepreneurship, and environmental careers.

## PROGRAMME OUTCOMES

|              |                                                                                                                                                                                                                                                                                 |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PO 1</b>  | <b>Communication Skill:</b> Mandatory language courses facilitate to become proficient in communication, culturally aware, and more employable in both Indian and global contexts. Improve presentations skill, debates, and professional communication.                        |
| <b>PO 2</b>  | <b>Disciplinary Knowledge:</b> Learn in-depth complex scientific concepts, demonstrate their ability to explain and apply their knowledge. Consistent in learning by earning extra credits in specialized courses within the science domain and enhance disciplinary knowledge. |
| <b>PO 3</b>  | <b>Critical thinking:</b> Field and academic visits will help students to develop observation skills, grasping ability, collect and interpret data and propose models that will help them to understand hypotheses and conclusions.                                             |
| <b>PO 4</b>  | <b>Analytical Reasoning:</b> Through the interactions, students will develop skills of critical reading of texts, identifying gaps in knowledge, formulating scientific questions, and on will recognizing the synthesis of new ideas.                                          |
| <b>PO 5</b>  | <b>Scientific Reasoning:</b> Skill oriented courses will provide details on principles, conduct of proper calibration and use of scientific instrumentation and appropriate use of scientific techniques in experimental design                                                 |
| <b>PO 6</b>  | <b>Self-directed Learning:</b> Preparation of field reports helps them to present their results and discussion in a written format that is typically required for their future professions.                                                                                     |
| <b>PO 7</b>  | <b>Reflective Thinking:</b> All core courses with laboratory components will provide exposure to a wide range of research techniques, therein enhancing their understanding of the application of techniques in their domain.                                                   |
| <b>PO 8</b>  | <b>Problem Solving:</b> Students will develop the ability to reason, apply numerical concepts, and equations in their fields of study for interpreting scientific data and drawing relevant scientific conclusions.                                                             |
| <b>PO 9</b>  | <b>Research-related Skills:</b> Students undertaking a internship will have the opportunity to design, develop and execute their own research ideas in their experiments, thus expanding their knowledge of research methods and laboratory skills.                             |
| <b>PO 10</b> | <b>Lifelong Learning:</b> Ability to understand the gaps in knowledge and skill, adapt to technological change, engage in self-directed learning.                                                                                                                               |

Code:

**FUNDAMENTALS OF  
ENVIRONMENTAL SCIENCE  
(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To introduce the fundamental concepts and principles of Environmental Science.
- To understand the structure and functioning of the environment and its components.
- To gain knowledge of ecosystems, biodiversity, natural resources, and environmental issues.
- To develop awareness of environmental conservation and sustainable development.
- To understand the role of humans in environmental management and protection.

**UNIT – I: INTRODUCTION TO ENVIRONMENTAL SCIENCE**

Environmental Science: Definition, scope, importance, and multidisciplinary nature. Components of the environment – atmosphere, hydrosphere, lithosphere, and biosphere. Structure and functions of the environment. Human-environment interactions. Concept of sustainability and sustainable development. Environmental ethics and environmental awareness.

**UNIT – II: ECOSYSTEMS**

Concept, structure, and functions of ecosystems. Components of ecosystems: abiotic and biotic factors. Types of ecosystems – terrestrial and aquatic ecosystems. Energy flow in ecosystems. Food chains, food webs, and ecological pyramids. Biogeochemical cycles – water cycle, carbon cycle, nitrogen cycle, and oxygen cycle.

**UNIT – III: BIODIVERSITY AND ITS CONSERVATION**

Definition and levels of biodiversity – genetic, species, and ecosystem diversity. Importance and values of biodiversity. Biogeographical zones of India. Threats to biodiversity. Endangered and endemic species. In-situ and ex-situ conservation methods. Protected areas – biosphere reserves, national parks, and wildlife sanctuaries.

**UNIT – IV: NATURAL RESOURCES**

Natural resources – classification and importance. Forest resources, water resources, mineral resources, land resources, and energy resources. Renewable and non-renewable resources. Conservation and sustainable utilization of natural resources. Environmental impacts of resource exploitation.

## **UNIT – V: ENVIRONMENTAL POLLUTION AND MANAGEMENT**

Concept and types of pollution – air, water, soil, noise, thermal, and radioactive pollution. Sources, effects, and control measures of pollution. Solid waste management, e-waste management, and biomedical waste management. Climate change, global warming, ozone depletion, and acid rain. Environmental management and pollution control strategies.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

World Environment Day. Earth Day. Sustainable Development Goals (SDGs). Climate Change and Carbon Neutrality. Plastic Pollution and Microplastics. Renewable Energy Technologies. Circular Economy. Green Technologies and Waste-to-Energy Systems.

## **REFERENCES**

1. Cunningham, W.P. and Cunningham, M.A. (2019). Environmental Science: A Global Concern. McGraw Hill.
2. Botkin, D.B. and Keller, E.A. (2011). Environmental Science: Earth as a Living Planet. John Wiley & Sons.
3. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
4. Santra, S.C. (2019). Environmental Science. New Central Book Agency.
5. Joseph, K. and Nagendran, R. (2004). Essentials of Environmental Studies. Pearson Education.
6. Purohit, S.S., Shammi, Q.J. and Agarwal, A.K. (2018). A Textbook of Environmental Science. Student Edition.
7. Anjaneyulu, Y. (2009). Introduction to Environmental Science. BSP Books.
8. Odum, E.P. and Barrett, G.W. (2005). Fundamentals of Ecology. Thomson Brooks/Cole.
9. Miller, G.T. and Spoolman, S. (2021). Environmental Science. Cengage Learning.
10. Rajagopalan, R. (2016). Environmental Studies: From Crisis to Cure. Oxford University Press.

### Course Outcomes (COs)

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

| CO No. | Course Outcomes                                                                                                                                         |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO1    | Understand the definition, scope, and multidisciplinary nature of Environmental Science and its role in addressing global environmental challenges.     |
| CO2    | Explain the structure, components, and functioning of the environment including atmosphere, hydrosphere, lithosphere, and biosphere.                    |
| CO3    | Describe the concept, structure, and types of ecosystems and analyze the energy flow through food chains, food webs, and ecological pyramids.           |
| CO4    | Explain biogeochemical cycles—water, carbon, nitrogen, and oxygen—and their significance in maintaining ecological balance.                             |
| CO5    | Describe the levels of biodiversity, its ecological and economic values, and identify biogeographical zones, endemic and endangered species in India.   |
| CO6    | Analyze the causes, consequences, and conservation strategies related to biodiversity loss including in-situ and ex-situ approaches.                    |
| CO7    | Classify natural resources and assess the environmental impacts of their exploitation and sustainable management strategies.                            |
| CO8    | Analyze the sources, types, effects, and control measures of air, water, soil, noise, thermal, and radioactive pollution.                               |
| CO9    | Evaluate the concepts of climate change, global warming, ozone depletion, acid rain, and their global and regional environmental implications.          |
| CO10   | Develop awareness and responsibility towards environmental conservation, sustainable development, and the need for environmental ethics and management. |

### CO-PO Mapping Matrix

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 1   | 1   | 2   | 2   | 1   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 1   | 2    |
| CO6       | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 3    |
| CO7       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO9       | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 3    |
| CO10      | 3   | 3   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

Code:

**ENVIRONMENTAL SCIENCE LAB  
(Practical)****Credits: 4****COURSE OBJECTIVES**

- To provide practical exposure to fundamental concepts of Environmental Science.
- To develop skills in environmental sampling, analysis, and interpretation of environmental data.
- To familiarize students with ecosystem components, biodiversity assessment, and environmental monitoring techniques.
- To understand environmental quality parameters and their significance in environmental management.
- To create awareness regarding environmental conservation through field-based observations and laboratory experiments.

**PRACTICAL EXERCISES**

1. Identification and classification of environmental components: atmosphere, hydrosphere, lithosphere, and biosphere.
2. Identification of common aquatic and terrestrial organisms and their ecological significance.
3. Preparation and submission of ten herbarium specimens with proper field notes.
4. Study of food chains, food webs, and ecological pyramids through diagrammatic representation.
5. Preparation of environmental awareness materials (posters/charts/models) on environmental issues.

**REFERENCES**

1. Trivedi, R.K., Goel, P.K. and Trisal, C.L. Practical Methods in Ecology and Environmental Science. Environmental Publications, Karad, 1987.
2. APHA. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington D.C.
3. Margesin, R. and Schinner, F. Manual of Soil Analysis: Monitoring and Assessing Bioremediation. Springer, 2005.
4. Odum, E.P. and Barrett, G.W. Fundamentals of Ecology. Thomson Brooks/Cole, 2005.
5. Sharma, P.D. Ecology and Environment. Rastogi Publications, Meerut.

6. Santra, S.C. Environmental Science. New Central Book Agency, Kolkata.
7. Trivedy, R.K. Handbook of Environmental Analysis. Scientific Publishers, Jodhpur.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                        |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Identify and classify major environmental components—atmosphere, hydrosphere, lithosphere, and biosphere—through direct observation and practical exercises. |
| <b>CO2</b>    | Recognize and describe common aquatic and terrestrial organisms and explain their roles in ecological systems.                                               |
| <b>CO3</b>    | Prepare and document scientific herbarium specimens with accurate field notes following standard botanical practices.                                        |
| <b>CO4</b>    | Illustrate food chains, food webs, and ecological pyramids through diagrammatic representation and relate them to energy transfer in ecosystems.             |
| <b>CO5</b>    | Prepare environmental awareness materials such as posters, charts, and models on current environmental issues.                                               |
| <b>CO6</b>    | Develop practical skills in environmental sampling, field observation, and data recording for ecological studies.                                            |
| <b>CO7</b>    | Communicate environmental observations effectively through scientific reports and field documentation.                                                       |
| <b>CO8</b>    | Apply basic ecological concepts and methods to analyze environmental data collected during laboratory and field exercises.                                   |
| <b>CO9</b>    | Demonstrate environmental responsibility and awareness through active participation in conservation-related practical activities.                            |
| <b>CO10</b>   | Develop scientific temperament and laboratory safety practices essential for environmental science fieldwork and experimentation.                            |

**CO-PO Mapping Matrix**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 1   | 1   | 2   | 2   | 1   | 1   | 1   | 1    |
| CO2       | 1   | 3   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 2   | 2   | 1   | 1   | 1   | 2   | 2   | 1   | 1   | 1    |
| CO4       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 3   | 2   | 2   | 1   | 1   | 2   | 1   | 1   | 1   | 2    |
| CO6       | 1   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 2   | 2    |
| CO7       | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 2    |
| CO8       | 1   | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2    |
| CO9       | 3   | 2   | 2   | 1   | 1   | 3   | 3   | 1   | 1   | 3    |
| CO10      | 1   | 2   | 2   | 1   | 2   | 3   | 2   | 2   | 2   | 3    |

Code:

**BIOLOGY I -  
PLANT DIVERSITY AND PHYSIOLOGY,  
MUSHROOM TECHNOLOGY AND PLANT  
BIOTECHNOLOGY  
(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To expose the diversity of plant kingdom and their salient features
- To acquire skills for engaging themselves in self-employment especially in the broad
- field of Mushroom Culture.
- To expose various avenues of opportunities in the field of plant biotechnology
- considering its recognition, importance and utility value.

**UNIT – I:**

Algae: General characteristics of algae and its importance. Structure, reproduction and life cycle of Nostoc, Chlorella, Oedogonium, Ectocarpus and Polysiphonia. Fungi: General characteristics of fungi and its importance. Structure of Albigo and Penicillium.

**UNIT - II:**

Bryophytes: General characteristics of bryophytes. Structure, reproduction and life cycle of Riccia and Polytrichum. Pteridophytes: General characteristics of pteridophytes. Structure, reproduction and life cycle of Lycopodium. Gymnosperms: General characteristics of gymnosperms and its importance. Structure, reproduction and life cycle of Cycas.

**UNIT - III:**

Plant Physiology: Absorption of water. Photosynthesis – Light and dark reaction (C3 cycle only). Respiration. Plant movements.

**UNIT - IV:**

Mushroom Technology: Mushroom: Introduction, nutritive value and importance of mushrooms. Cultivation of Oyster mushroom - spawn preparation, preservation of mushrooms, and mushrooms recipes.

**UNIT - V:**

Plant Biotechnology: Plant tissue culture - basic principles, M.S. medium preparation, Callus culture and regeneration

## **UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):**

Biodiversity, Hot Spots of Biodiversity, Biogeographical classification of India, CBD, UNEP

### **REFERENCES:**

1. Chang, T.S. and Hayes, W.A. 1978. The Biology and Cultivation of Edible Mushrooms. Academic Press, New York.
2. M.C. Nair, C. Gokulapalan and Lulu Das, 1997. Topics on Mushroom Cultivation. Scientific Publishers, Jodhpur, India.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology (4th edition). John Wiley and Sons (Asia), Singapore.
4. Alice, D., Muthusamy and Yesuraja, M. (1999). Mushroom Culture. Agricultural College, Research Institute Publications, Madurai.
5. Dubey, R.C. (2013). A Textbook of Biotechnology. S. Chand & Company Ltd., New Delhi.
6. Ganguly A.K. (1971). General Botany, Vol. I. The New Book Stall, Calcutta.
7. Gupta, P.K. (1994). Elements of Biotechnology. Restogi Publications, Meerut.
8. Ignacimuthu, S. (1997). Plant Biotechnology. Oxford & IBM Publishing Co., New Delhi.
9. Jain, V.K. (1990). Fundamentals of Plant Physiology. S. Chand & Co., New Delhi.
10. Kalyan Kumar De. (1997). Plant Tissue culture. New central Book Agency, Calcutta.
11. Kumar, H.D. (1991). A Textbook on Biotechnology. East west press, New Delhi.
12. Marimuthu, T. (1991). Oyster Mushroom. Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
13. Nita Bhal (2000). Handbook on Mushrooms Vol. I and II (2nd Ed.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
14. Noggle, R. and Fritz (1989). Introductory Plant Physiology. Prentice Hall of India.
15. Pandey, B.P. (2001). College Botany Vol. I: Algae, Fungi, Lichens, Bacteria, Viruses, Plant Pathology, Industrial Microbiology and Bryophyta. S. Chand & Company Ltd., New Delhi.
16. Pandey, S.N. (1991). Plant Physiology. Vikas Publishing House (P) Ltd., New Delhi.
17. Parihar, P. (2014). A Textbook of Biotechnology. Argobios Publications, Jodhpur
18. Pathak, V.N. and Yadav, N. (1998). Mushroom Production and Processing Technology. Agrobios, Jodhpur.
19. Rao K.N. Krishnamurthy K.V. and Rao G. (1979). Ancillary Botany. Viswanathan Pvt. Ltd., Chennai.
20. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies. MacMillan Publishers Pvt. Ltd., Delhi.

21. Suman B.C. and Sharma V.P. (1990). Mushroom Cultivation and Uses. Agrobios (India), Jodhpur. Tripathi, D.P. 2005. Mushroom Cultivation. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
22. [www.unapcaem.org](http://www.unapcaem.org).
23. <https://apeda.gov.in> › apedawebsite › organic
24. <https://extension.psu.edu/six-steps-to-mushroom-farming>
25. <https://www.mushroomcouncil.com/growing-mushrooms/six-steps-to-mushroomfarming>

### **COURSE OUTCOMES:**

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

CO1: Explain the diversity, classification, life cycles, and economic importance of algae and fungi with suitable examples.

CO2: Describe the morphology, reproduction, life cycles, and evolutionary significance of bryophytes, pteridophytes, and gymnosperms.

CO3: Explain the fundamental physiological processes in plants, including water absorption, photosynthesis, respiration, and plant movements.

CO4: Demonstrate knowledge of the nutritional value, economic importance, cultivation methods, harvesting, preservation, and value-added products of oyster mushrooms.

CO5: Apply the basic principles and techniques of mushroom cultivation for small-scale production and entrepreneurial opportunities.

CO6: Explain the principles, applications, and laboratory techniques involved in plant tissue culture, including MS medium preparation, callus culture, and plant regeneration.

CO7: Describe the applications of plant biotechnology in agriculture, horticulture, conservation, and sustainable crop improvement.

CO8: Analyze the commercial potential of mushroom cultivation and plant biotechnology in promoting rural development, food security, and self-employment.

CO9: Demonstrate awareness of biodiversity, biodiversity hotspots, the biogeographical classification of India, and international conservation initiatives such as the Convention on Biological Diversity (CBD) and the United Nations Environment Programme (UNEP).

CO10: Develop scientific inquiry, practical skills, and environmental responsibility through the study of plant diversity, physiology, biotechnology, and sustainable biological resource utilization.

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 1   | 1   | 1   | 1   | -   | 2    |
| CO2       | 1   | 3   | 3   | 2   | 2   | 1   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 1   | 2   | 2   | 1   | 2    |
| CO4       | 2   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 3    |
| CO5       | 2   | 3   | 2   | 2   | 3   | 3   | 2   | 3   | 2   | 3    |
| CO6       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO7       | 2   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 3    |
| CO8       | 2   | 3   | 3   | 3   | 2   | 3   | 2   | 3   | 2   | 3    |
| CO9       | 2   | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 3    |
| CO10      | 2   | 3   | 3   | 2   | 3   | 3   | 3   | 3   | 3   | 3    |

Code:

**BIOLOGY LABORATORY**  
**(Practical)**

Credits: \*\*

**COURSE OBJECTIVES:**

Upon completion of this practical course, students will be able to:

- Identify and describe the basic structures of algae, fungi, bryophytes, pteridophytes, gymnosperms, and flowering plants using specimens and slides.
- Observe and understand the internal structure of plant parts such as roots, stems, leaves, anthers, and ovules through microscopic studies.
- Recognize plant families based on their important morphological features and perform flower dissection with floral diagrams and formulae.
- Perform simple plant physiology experiments and understand processes such as water absorption, transpiration, and photosynthesis.
- Demonstrate basic plant propagation techniques and develop skills in slide preparation, laboratory observation, identification, recording, and safe laboratory practices

**EXPERIMENTS**

1. Micro preparations of algae, fungi, bryophytes, pteridophytes, gymnosperms and demonstrating their description and identity included in the syllabus.
2. Micro preparations of stem, root and leaf of dicot and their identification.
3. Micro preparation of anther and observation of ovules (permanent slides).
4. Description of the plants and salient features of the families included in the syllabus.
5. Dissection flower and construction of floral diagram.
6. Comment on simple experimental setups in plant physiology included in the syllabus.
7. Propagation techniques.

**COURSE OUTCOMES:**

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

CO1: Prepare, observe, identify, and describe the microscopic features of representative algae, fungi, bryophytes, pteridophytes, and gymnosperms.

CO2: Identify the anatomical characteristics of dicot stem, root, and leaf through microscopic examination and distinguish their structural features.

CO3: Demonstrate the preparation and observation of

reproductive structures such as anther and ovules using temporary and permanent slides.

CO4: Identify major plant families based on diagnostic morphological characters and classify specimens using standard taxonomic keys.

CO5: Perform floral dissection, construct floral diagrams and floral formulae, and interpret floral characteristics for plant identification.

CO6: Conduct and interpret simple plant physiology experiments related to water absorption, transpiration, photosynthesis, and other physiological processes.

CO7: Demonstrate different plant propagation techniques and explain their applications in agriculture, horticulture, and conservation.

CO8: Develop proficiency in handling laboratory instruments, preparing slides, recording observations, and maintaining practical records.

CO9: Apply practical knowledge of plant anatomy, taxonomy, and physiology to accurately identify unknown plant specimens and interpret laboratory results.

CO10: Demonstrate scientific skills, observational ability, teamwork, and ethical laboratory practices necessary for higher studies and biological research.

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 3   | 2   | 3   | 1   | 2   | 2   | 2   | 2    |
| CO2       | 1   | 3   | 3   | 2   | 3   | 1   | 2   | 2   | 2   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 3   | 2    |
| CO4       | 2   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 2   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO6       | 2   | 3   | 2   | 2   | 3   | 2   | 2   | 3   | 3   | 2    |
| CO7       | 2   | 3   | 2   | 2   | 3   | 3   | 2   | 3   | 2   | 3    |
| CO8       | 2   | 2   | 2   | 2   | 3   | 3   | 3   | 2   | 3   | 3    |
| CO9       | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 3    |
| CO10      | 2   | 2   | 2   | 2   | 3   | 3   | 3   | 2   | 3   | 3    |

Code:

**CONCEPTS OF ECOLOGY  
(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To understand the fundamental principles and concepts of ecology and ecosystem functioning.
- To gain knowledge about the interactions between organisms and their environment.
- To study ecological processes governing populations, communities, and ecosystems.
- To understand biodiversity, ecological succession, and biogeochemical cycles.
- To appreciate the role of ecology in environmental conservation and sustainable development.

**UNIT – I: INTRODUCTION TO ECOLOGY**

Ecology: Definition, scope, branches, and significance; Historical development of ecology; Levels of ecological organization – organism, population, community, ecosystem, biome, and biosphere; Habitat and ecological niche; Abiotic and biotic components of ecosystems; Ecological factors and adaptations.

**UNIT – II: POPULATION ECOLOGY**

Population ecology: Characteristics of populations – density, natality, mortality, age structure, dispersion, and growth forms; Population growth curves (J-shaped and S-shaped); Carrying capacity; Population regulation; Population interactions – competition, predation, parasitism, mutualism, commensalism, and amensalism.

**UNIT – III: COMMUNITY ECOLOGY**

Community ecology: Concept and characteristics of ecological communities; Community structure and organization; Species diversity and abundance; Ecological succession – primary and secondary succession; Ecotone and edge effect; Community stability and resilience.

**UNIT – IV: ECOSYSTEM ECOLOGY**

Ecosystem: Structure and functions; Types of ecosystems – terrestrial and aquatic ecosystems; Energy flow in ecosystems; Food chains, food webs, and ecological pyramids; Productivity of ecosystems – primary and secondary productivity; Ecosystem services and their significance.

**UNIT – V: BIODIVERSITY AND BIOGEOCHEMICAL CYCLES**

Biodiversity: Concept, levels, and importance; Patterns of biodiversity distribution; Threats to biodiversity and conservation

strategies; Biogeochemical cycles – water cycle, carbon cycle, nitrogen cycle, phosphorus cycle, and sulfur cycle; Ecological significance of nutrient cycling.

### **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

World Biodiversity Day; Ecosystem Restoration; Climate Change and Ecosystem Resilience; Invasive Alien Species; Nature-based Solutions; Ecological Footprint; Sustainable Ecosystem Management; Citizen Science in Biodiversity Conservation.

### **REFERENCES**

1. Odum, E.P. and Barrett, G.W. (2005). Fundamentals of Ecology. Thomson Brooks/Cole.
2. Begon, M., Townsend, C.R. and Harper, J.L. (2006). Ecology: From Individuals to Ecosystems. Blackwell Publishing.
3. Krebs, C.J. (2014). Ecology: The Experimental Analysis of Distribution and Abundance. Pearson Education.
4. Smith, T.M. and Smith, R.L. (2015). Elements of Ecology. Pearson Education.
5. Ricklefs, R.E. and Relyea, R. (2018). Ecology: The Economy of Nature. W.H. Freeman.
6. Chapman, J.L. and Reiss, M.J. (1999). Ecology: Principles and Applications. Cambridge University Press.
7. Molles, M.C. (2019). Ecology: Concepts and Applications. McGraw-Hill Education.
8. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
9. Kormondy, E.J. and Brown, D.E. (2008). Fundamentals of Human Ecology. Pearson Education.
10. Cunningham, W.P. and Cunningham, M.A. (2020). Environmental Science: A Global Concern. McGraw-Hill Education.
11. Chapin III, F.S., Matson, P.A. and Vitousek, P.M. (2012). Principles of Terrestrial Ecosystem Ecology. Springer.
12. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environment and Resource Conservation. Anamaya Publishers.
13. Miller, G.T. and Spoolman, S. (2018). Living in the Environment. Cengage Learning.
14. Verma, P.S. and Agarwal, V.K. (2019). Environmental Biology and Ecology. S. Chand Publications.
15. Dash, M.C. (2001). Fundamentals of Ecology. Tata McGraw-Hill.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                        |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the definition, scope, branches, and significance of ecology, and describe the levels of ecological organization from organism to biosphere.               |
| <b>CO2</b>  | Explain population characteristics such as density, natality, mortality, age structure, and growth forms including J-shaped and S-shaped growth curves.               |
| <b>CO3</b>  | Analyze population interactions—competition, predation, parasitism, mutualism, commensalism, and amensalism—and their ecological significance.                        |
| <b>CO4</b>  | Describe the structure and organization of ecological communities, including species diversity, ecological succession, ecotone, edge effect, and community stability. |
| <b>CO5</b>  | Explain ecosystem structure, functions, energy flow pathways, and productivity concepts including primary and secondary productivity.                                 |
| <b>CO6</b>  | Describe major terrestrial and aquatic ecosystems and evaluate the ecosystem services they provide.                                                                   |
| <b>CO7</b>  | Analyze the levels, patterns, and distribution of biodiversity and identify major threats to biodiversity conservation.                                               |
| <b>CO8</b>  | Explain biogeochemical cycles—water, carbon, nitrogen, phosphorus, and sulfur—and assess their ecological significance in nutrient recycling.                         |
| <b>CO9</b>  | Apply ecological principles to address real-world environmental management and sustainable development challenges.                                                    |
| <b>CO10</b> | Evaluate emerging ecological concepts such as ecosystem restoration, climate change impacts on ecosystems, invasive species, and nature-based solutions.              |

## CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 1   | 3   | 2   | 2   | 3   | 2   | 3   | 2   | 1   | 2    |
| CO6       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 3    |
| CO8       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO9       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 2   | 3    |
| CO10      | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

Code:

**ECOLOGY LAB**  
**(Practical)****Credits: 4****COURSE OBJECTIVES**

- To understand fundamental ecological concepts through field and laboratory exercises.
- To familiarize students ecological observations.
- To develop skills in the identification and quantification of plants and animals in different habitats.
- To introduce ecological data collection, analysis, and interpretation.

**EXPERIMENTS**

1. Study of ecological factors: Measurement of temperature, light intensity, humidity, and soil moisture.
2. Identification and classification of common terrestrial plants and animals in the local environment.
3. Study of food chains and food webs in different ecosystems.
4. Determination of primary productivity using simple aquatic ecosystem models.
5. Visit to a protected area, botanical garden, zoological park, or biodiversity park and submission of a field report.

**COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                          |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Measure and record ecological abiotic factors such as temperature, light intensity, humidity, and soil moisture using appropriate instruments. |
| <b>CO2</b>    | Identify and classify common terrestrial plants and animals in the local environment using standard taxonomic references.                      |
| <b>CO3</b>    | Construct food chains and food webs for different ecosystems and explain energy transfer mechanisms.                                           |
| <b>CO4</b>    | Determine primary productivity of simple aquatic ecosystems using standard experimental models.                                                |
| <b>CO5</b>    | Conduct field visits to protected areas or biodiversity parks and prepare detailed field reports on ecological observations.                   |
| <b>CO6</b>    | Apply simple ecological sampling methods including quadrat and transect techniques to collect and analyze field data.                          |
| <b>CO7</b>    | Develop skills in ecological data collection,                                                                                                  |

|             |                                                                                                                                          |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------|
|             | organization, and interpretation for biodiversity and ecosystem assessment.                                                              |
| <b>CO8</b>  | Understand the principles of ecosystem management through direct observation of natural habitats and ecological processes.               |
| <b>CO9</b>  | Demonstrate teamwork, field safety, and ethical practices during ecological fieldwork and laboratory exercises.                          |
| <b>CO10</b> | Relate practical ecological findings to theoretical concepts learned in the classroom for holistic understanding of ecological sciences. |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 1   | 1   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO2       | 1   | 3   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 2   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 1    |
| CO5       | 3   | 2   | 2   | 2   | 1   | 3   | 3   | 1   | 2   | 2    |
| CO6       | 1   | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 2   | 2    |
| CO7       | 2   | 2   | 3   | 3   | 2   | 3   | 2   | 2   | 2   | 2    |
| CO8       | 1   | 3   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO9       | 2   | 1   | 2   | 1   | 1   | 2   | 2   | 1   | 1   | 2    |
| CO10      | 1   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 1   | 3    |

Code:

**BIOLOGY II -  
ANIMAL DIVERSITY, ADOPTATION  
AND BEHAVIOUR  
(Theory)**

Credits: 4

**COURSE OBJECTIVES:**

- To comprehend and analyze the adaptive changes that have occurred in invertebrates & vertebrates
- To comprehend the genetics, anatomy, physiology and behavior along with other specialized fields of interest
- To recognize and describe the basic habit, habitat & behavior of chordates

**UNIT – I DIVERSITY OF INVERTEBRATES AND CHORDATES:**

Kingdom Animalia: Salient features - levels of organization: cellular, tissue, organ and organ system; Classification of major Invertebrata Phyla and Phylum Chordata up to classes - General characters and diversity of Major Invertebrata Phyla and Phylum Chordata with suitable examples.

**UNIT – II BENEFICIAL INSECTS, VERMICULTURE AND PARASITOLOGY:**

Detailed study: Earthworm –Cockroach- Pigeon. Economic importance of beneficial insects - Social life of honey bees. Brief study of Vermiculture, vermicomposting and its applications. Parasitology-Vector borne diseases–Malaria, Dengue.

**UNIT – III ADAPTIVE RADIATION IN CHORDATES:**

Biological significance of Migratory animals: Fishes, Birds and Mammals. Flight adaptations in vertebrates - Aquatic adaptations in birds and mammals; embryonic adaptation: Extra embryonic membrane structure in Reptiles and Birds. Adaptive radiations in chordates: Aquatic, terrestrial and arboreal. Bio indicators-microbes.

**UNIT – IV ANIMAL BEHAVIOUR AND PHEROMONES:**

Animal Behaviour: Stereotyped behaviour- instincts and motivation; Acquired behaviour: Pavlovian learning, trial and error learning. Pheromones and behaviour: types, significance – Pheromones with reference to insects and rodents.

**UNIT – V SOCIAL BEHAVIOUR IN ANIMALS:**

Social behaviour: Birds, primates. Biological rhythms: circadian, tidal, lunar, circannual rhythms. Types of communication in animals: visual, olfactory, tactile, verbal and non-verbal-Communication in bees and birds. mimicry and animal colorations.

## **UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):**

Hots spots of India, Types of Biodiversity, Biogeographical classification, IUCN, Red Data Book

### **REFERENCES:**

1. Jordan E.L. and Verma P.S., Invertebrate Zoology, 12th edn. Schand & Co. 1995.
2. Kotpal R.L., Agarwal, R.P.R., Khertarpa, Modern Text Book of Zoology-I – Rastogi Publications. 1989.
3. Ayyar E.K. Ananthakrishnan, T.N., Outlines of Zoology: Invertebrata, Vol-I and Vol-II Viswanathan Pvt. Ltd. 1993.
4. Hoshang. S, Gundevia and Hare Govind Singh, A textbook of Animal Behaviour, Chand & Co., 1997.
5. Shukla G.S and Upadhyay V.B., Economic Zoology, Rastogi Publications, 2004.
6. Jordan, E.L. and Verma P.S., Invertebrate Zoology, 12th edn. S.Chand & Co., 1995.
7. Reptilia (<https://www.notesonzooology.com/phylum-chordata/gardenlizard/external-morphology-of-garden-lizard-with-diagram-chordatazoology/8383>)
8. Vector borne diseases (<https://www.who.int/news-room/factsheets/detail/vector-borne-diseases>)
9. Apiculture (<https://www.sciencedirect.com/topics/earth-and-planetarysciences/apiculture>)

### **COURSE OUTCOMES (COS)**

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

CO1: Explain the fundamental characteristics, levels of organization, and classification of the animal kingdom, including major invertebrate phyla and chordate classes.

CO2: Identify and compare the structural and functional diversity of major groups of invertebrates and chordates using representative examples.

CO3: Describe the morphology, anatomy, physiology, and economic importance of selected animals such as earthworm, cockroach, and pigeon.

CO4: Discuss the significance of beneficial insects, particularly honey bees, and explain the principles, methods, and applications of vermiculture and vermicomposting.

CO5: Explain the causes, transmission, prevention, and control measures of major vector-borne diseases such as malaria and dengue.

CO6: Analyze the adaptive features of vertebrates for aquatic, terrestrial, arboreal, migratory, and aerial modes of life, including embryonic adaptations in reptiles and birds.

CO7: Differentiate between innate and learned animal behaviours and explain the role of pheromones in communication and behavioural responses.

CO8: Describe various forms of social behaviour, biological

rhythms, mimicry, animal coloration, and communication strategies in birds, bees, primates, and other animals.

CO9: Evaluate the ecological importance of animals as bioindicators and recognize their role in maintaining ecosystem health and biodiversity conservation.

CO10: Demonstrate awareness of India's biodiversity hotspots, biogeographical classification, biodiversity types, and global conservation initiatives including the IUCN and the Red Data Book, fostering responsible environmental stewardship.

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 1   | 1   | 1   | 1   | -   | 2    |
| CO2       | 1   | 3   | 3   | 2   | 2   | 1   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 1   | 2   | 2   | 1   | 2    |
| CO4       | 2   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 3    |
| CO5       | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 3   | 1   | 3    |
| CO6       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO7       | 2   | 3   | 2   | 3   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO8       | 2   | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 2    |
| CO9       | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 3    |
| CO10      | 2   | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 3    |

Code:

**BIOLOGY LABORATORY**  
**(Practical)****Credits: 4****COURSE OBJECTIVES**

- To provide practical knowledge of the diversity and classification of major invertebrates and vertebrates.
- To develop skills in identifying economically and ecologically important animal species based on morphological characteristics.
- To familiarize students with the adaptations and behavioural patterns of animals through simple laboratory observations and demonstrations.
- To impart basic knowledge on vermiculture, apiculture, vector-borne diseases, and biodiversity conservation through practical exercises.
- To develop scientific observation, specimen handling, and practical record-keeping skills.

**LIST OF PRACTICALS**

**1. Identification of Invertebrate Specimens:** Study and identify representative specimens belonging to the major invertebrate phyla included in the syllabus (Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Arthropoda, Mollusca and Echinodermata).

**2. Identification of Chordate Specimens:** Study and identify representative specimens of Pisces, Amphibia, Reptilia, Aves and Mammalia based on external morphology and diagnostic characters.

**3. Earthworm:** Study the external morphology and identify important external features and adaptive characteristics of the earthworm.

**4. Cockroach:** Study the external morphology and appendages of the cockroach and identify its adaptive features.

**5. Pigeon:** Study the external features, feathers, beak and feet modifications of pigeon and correlate them with flight adaptation.

**6. Beneficial Insects:** Identification and economic importance of honey bee, silkworm and lac insect. Study the structure of a bee hive (demonstration/model).

**7. Vermiculture and Vermicomposting:** Preparation of a small vermicomposting unit, identification of composting stages and observation of compost quality.

**8. Animal Behaviour**

Observation of behavioural patterns through videos/models such as:

Nest building

Parental care

Courtship behaviour

Social behaviour in honey bees

**9. Vector-Borne Diseases:** Identification of mosquito larvae (Aedes and Anopheles) using charts/models and study of the life cycle of mosquitoes and preventive measures for malaria and dengue.

**10. Biodiversity and Conservation:** Identification of endangered, endemic and threatened animals of India using charts, photographs and museum specimens. Preparation of a simple checklist of local animal diversity.

### **COURSE OUTCOMES (COS)**

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

CO1: Identify major invertebrate and vertebrate groups based on their distinguishing morphological characteristics.

CO2: Demonstrate knowledge of the external morphology and adaptive features of selected animals such as earthworm, cockroach, and pigeon.

CO3: Explain the ecological and economic importance of beneficial insects and apply the basic principles of vermiculture and vermicomposting.

CO4: Observe and interpret different behavioural patterns in animals, including social behaviour, communication, and parental care.

CO5: Identify disease vectors and explain the transmission, prevention, and control measures of common vector-borne diseases.

CO6: Compare adaptive modifications of animals inhabiting aquatic, terrestrial, arboreal, and aerial environments.

CO7: Demonstrate proficiency in specimen handling, observation, identification, and maintenance of practical records.

CO8: Apply taxonomic knowledge to classify unknown animal specimens using diagnostic features.

CO9: Develop awareness of biodiversity conservation, endangered species, and the ecological importance of bioindicators.

CO10: Demonstrate scientific observation, teamwork, laboratory ethics, and basic research skills required for biological studies.

### **CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 3   | 2   | 2   | 1   | 2   | 2   | 2   | 2    |
| CO2       | 1   | 3   | 3   | 2   | 3   | 1   | 2   | 2   | 2   | 2    |
| CO3       | 2   | 3   | 2   | 2   | 3   | 2   | 2   | 3   | 2   | 3    |
| CO4       | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2   | 2    |
| CO5       | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 3   | 2   | 3    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO7       | 2   | 2   | 2   | 2   | 3   | 3   | 3   | 2   | 3   | 3    |
| CO8       | 2   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 3   | 2    |
| CO9       | 2   | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 3    |
| CO10      | 2   | 2   | 2   | 2   | 3   | 3   | 3   | 2   | 3   | 3    |

Code:

**NATURAL RESOURCES AND  
BIODIVERSITY  
(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To provide an understanding of the types, distribution, and utilization of natural resources.
- To introduce the concepts, values, and significance of biodiversity.
- To examine the causes and consequences of resource depletion and biodiversity loss.
- To understand the principles and practices of natural resource conservation and sustainable management.
- To develop awareness of national and global initiatives for biodiversity conservation.

**UNIT – I: NATURAL RESOURCES**

Natural Resources: Definition, classification, and importance; Renewable and non-renewable resources; Natural resource distribution and utilization; Resource depletion and environmental consequences; Sustainable development and resource management.

**UNIT – II: FOREST, WATER, AND LAND RESOURCES**

Forest Resources: Types, distribution, uses, and ecological significance; Deforestation – causes, impacts, and conservation measures.

Water Resources: Surface and groundwater resources; Water scarcity, overexploitation, and conservation techniques; Rainwater harvesting and watershed management.

Land Resources: Land use and land cover; Land degradation, desertification, and soil erosion; Soil conservation and sustainable land management practices.

**UNIT – III: MINERAL, ENERGY, AND FOOD RESOURCES**

Mineral Resources: Types, extraction methods, environmental impacts of mining, and conservation of minerals.

Energy Resources: Conventional and non-conventional energy resources; Renewable energy sources – solar, wind, biomass, hydropower, geothermal, and tidal energy; Energy conservation and sustainable energy management.

Food Resources: Agricultural systems, food security, sustainable agriculture, organic farming, and agroforestry.

**UNIT – IV: BIODIVERSITY – CONCEPTS AND VALUES**

Biodiversity: Definition, levels, and importance; Genetic diversity, species diversity, and ecosystem diversity; Patterns of biodiversity

distribution; Biodiversity hotspots; Values of biodiversity – ecological, economic, social, cultural, ethical, aesthetic, and scientific values.

### **UNIT – V: BIODIVERSITY CONSERVATION**

Threats to Biodiversity: Habitat loss, fragmentation, invasive species, pollution, overexploitation, and climate change.

Conservation of Biodiversity: In-situ and ex-situ conservation; Protected area network – biosphere reserves, national parks, wildlife sanctuaries, conservation reserves, and community reserves; Biodiversity conservation policies and legislation; Role of local communities in conservation.

### **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

International Day for Biological Diversity; Kunming-Montreal Global Biodiversity Framework; Ecosystem Restoration; Nature-based Solutions; Sustainable Resource Management; Community-Based Conservation; Green Energy Transition; Biodiversity and Climate Change.

### **REFERENCES**

1. Gadgil, M. and Guha, R. (2013). This Fissured Land: An Ecological History of India. Oxford University Press.
2. Primack, R.B. (2020). Essentials of Conservation Biology. Sinauer Associates.
3. Groom, M.J., Meffe, G.K. and Carroll, C.R. (2006). Principles of Conservation Biology. Sinauer Associates.
4. Cunningham, W.P. and Cunningham, M.A. (2020). Environmental Science: A Global Concern. McGraw-Hill Education.
5. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environment and Resource Conservation. Anamaya Publishers.
6. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
7. Miller, G.T. and Spoolman, S. (2018). Living in the Environment. Cengage Learning.
8. Raven, P.H., Berg, L.R. and Hassenzahl, D.M. (2015). Environment. Wiley.
9. Convention on Biological Diversity (CBD) Documents and Reports.
10. National Biodiversity Authority, India – Publications and Guidelines.
11. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India Publications.
12. Bharucha, E. (2019). Textbook of Environmental Studies. Universities Press.

## COURSE OUTCOMES

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

| CO No. | Course Outcome                                                                                                                                                       |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO1    | Explain the classification, distribution, and utilization of natural resources including renewable and non-renewable types and their global significance.            |
| CO2    | Assess the environmental impacts of resource exploitation including deforestation, water scarcity, land degradation, and mineral extraction.                         |
| CO3    | Describe the principles and practices of sustainable forest, water, land, mineral, and energy resource management.                                                   |
| CO4    | Understand the concept, levels—genetic, species, ecosystem—and ecological, economic, social, cultural, and ethical values of biodiversity.                           |
| CO5    | Explain biodiversity hotspots, patterns of distribution, and their significance in conservation planning at national and global levels.                              |
| CO6    | Analyze major threats to biodiversity including habitat loss, fragmentation, invasive species, overexploitation, pollution, and climate change.                      |
| CO7    | Evaluate in-situ and ex-situ conservation strategies and the protected area network in India including biosphere reserves, national parks, and wildlife sanctuaries. |
| CO8    | Describe national and international biodiversity conservation policies and legislation including the Biological Diversity Act and CBD frameworks.                    |
| CO9    | Assess the role of local communities, indigenous knowledge systems, and community-based conservation in sustainable resource management.                             |
| CO10   | Apply knowledge of natural resources and biodiversity to promote sustainable development and participate in national and global conservation initiatives.            |

## CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1     | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2     | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 2    |
| CO3     | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 3    |
| CO4     | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO5     | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO6     | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 3    |
| CO7     | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 3    |
| CO8     | 2   | 3   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |
| CO9     | 2   | 2   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO10    | 3   | 3   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

Code:

**BIODIVERSITY LAB  
(Practical)****Credits: 4****COURSE OBJECTIVES**

- To familiarize students with the concepts and methods of biodiversity assessment.
- To develop skills in the identification and classification of flora and fauna.
- To introduce biodiversity monitoring techniques and ecological sampling methods.
- To provide practical exposure to biodiversity conservation and field documentation.

**LIST OF EXPERIMENTS****I. FLORISTIC DIVERSITY**

1. Identification and classification of common plant species using taxonomic keys.
2. Assessment of plant diversity using quadrat sampling method.
3. Estimation of density, frequency, abundance, and relative dominance of plant species.

**II. FAUNAL DIVERSITY**

1. Assessment of insect diversity using sweep net and pitfall trap methods.
2. Bird diversity survey using line transect and point count methods.
3. Documentation of local fauna and preparation of biodiversity checklists.

**III. BIODIVERSITY ASSESSMENT AND CONSERVATION**

1. Calculation of Species Richness Index.
2. Calculation of Shannon–Wiener Diversity Index.
3. Calculation of Simpson's Diversity Index.
4. Field visit to a protected area, biodiversity park, botanical garden, wildlife sanctuary, or community conservation site and submission of a field report.

**REFERENCES**

1. Trivedi, R.K. and Goel, P.K. Practical Methods in Ecology and Environmental Science. Environmental Publications, Karad, 1987.
2. Magurran, A.E. Measuring Biological Diversity. Blackwell Publishing, 2004.
3. Southwood, T.R.E. and Henderson, P.A. Ecological Methods. Wiley-Blackwell, 2009.
4. Krebs, C.J. Ecological Methodology. Benjamin Cummings, 1999.
5. Singh, J.S., Singh, S.P. and Gupta, S.R. Ecology,

- Environment and Resource Conservation. Anamaya Publishers, 2017.
6. Primack, R.B. Essentials of Conservation Biology. Sinauer Associates, 2020.
  7. Sharma, P.D. Ecology and Environment. Rastogi Publications, 2020.
  8. National Biodiversity Authority (NBA), India – Biodiversity Assessment Manuals and Guidelines.
  9. Zoological Survey of India (ZSI) Publications.
  10. Botanical Survey of India (BSI) Publications.

## **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                            |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Identify and classify common plant species using standard taxonomic keys and morphological characters in laboratory and field settings.          |
| <b>CO2</b>    | Apply the quadrat sampling method to assess plant diversity and estimate density, frequency, abundance, and relative dominance of plant species. |
| <b>CO3</b>    | Assess insect diversity using sweep net and pitfall trap methods and document findings with proper scientific records.                           |
| <b>CO4</b>    | Conduct bird diversity surveys using line transect and point count methods and prepare biodiversity checklists for local fauna.                  |
| <b>CO5</b>    | Calculate and interpret biodiversity indices including Species Richness Index, Shannon-Wiener Diversity Index, and Simpson's Diversity Index.    |
| <b>CO6</b>    | Prepare herbarium specimens and biodiversity inventories following standard scientific documentation practices.                                  |
| <b>CO7</b>    | Conduct field-based biodiversity surveys in protected areas, botanical gardens, or community conservation sites and produce detailed reports.    |
| <b>CO8</b>    | Evaluate the biodiversity status of local ecosystems and assess conservation needs based on field observations and data analysis.                |
| <b>CO9</b>    | Develop practical skills in ecological sampling, data recording, and biological monitoring for biodiversity assessment.                          |
| <b>CO10</b>   | Demonstrate scientific communication skills through preparation of biodiversity checklists, field reports, and specimen documentation.           |

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO3       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 1    |
| CO4       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 1    |
| CO5       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO6       | 2   | 2   | 1   | 1   | 1   | 2   | 2   | 1   | 1   | 2    |
| CO7       | 3   | 2   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO9       | 1   | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 2   | 2    |
| CO10      | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |

Code:

**ENVIRONMENTAL POLLUTION  
(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To provide a comprehensive understanding of environmental pollution and its impacts on ecosystems and human health.
- To introduce the sources, types, and characteristics of major environmental pollutants.
- To understand the methods of monitoring, prevention, and control of pollution.
- To familiarize students with environmental standards, regulations, and pollution management strategies.
- To develop awareness of sustainable approaches for pollution prevention and environmental protection.

**UNIT – I: INTRODUCTION TO ENVIRONMENTAL POLLUTION**

Environmental Pollution: Definition, concepts, types, and causes; Sources of pollution – natural and anthropogenic; Classification of pollutants; Primary and secondary pollutants; Environmental quality and environmental standards; Impacts of pollution on ecosystems and human health.

**UNIT – II: AIR POLLUTION**

Air Pollution: Sources, types, and effects of air pollutants; Particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, volatile organic compounds, and greenhouse gases; Smog – classical and photochemical smog; Acid rain; Indoor air pollution; Air quality monitoring and Air Quality Index (AQI); Prevention and control of air pollution.

**UNIT – III: WATER POLLUTION**

Water Pollution: Sources and types of water pollutants; Physical, chemical, and biological characteristics of water pollution; Surface water and groundwater contamination; Eutrophication; Waterborne diseases; Wastewater treatment – primary, secondary, and tertiary treatment; Water quality standards and water conservation measures.

**UNIT – IV: SOIL, NOISE, AND THERMAL POLLUTION**

Soil Pollution: Sources, causes, impacts, and remediation methods; Agricultural chemicals and heavy metal contamination. Noise Pollution: Sources, measurement, impacts on humans and wildlife; Noise standards and control measures. Thermal Pollution: Sources, impacts on aquatic ecosystems, and mitigation measures.

## **UNIT – V: SOLID WASTE, HAZARDOUS WASTE, AND RADIOACTIVE POLLUTION**

Solid Waste Management: Sources, composition, collection, segregation, transportation, and disposal methods; Municipal solid waste management.

Hazardous Waste: Characteristics, sources, treatment, and disposal.

Biomedical Waste and E-waste: Sources, impacts, and management practices.

Radioactive Pollution: Sources, effects, safety measures, and disposal of radioactive wastes.

Principles of Reduce, Reuse, Recycle, Recovery, and Circular Economy.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

National Clean Air Programme (NCAP); Plastic Pollution and Single-Use Plastics; Microplastics in Aquatic Ecosystems; E-Waste Management; Swachh Bharat Mission; Sustainable Waste Management; Green Technologies for Pollution Control; Environmental, Social and Governance (ESG) Practices.

## **REFERENCES**

1. Rao, C.S. (2018). Environmental Pollution Control Engineering. New Age International Publishers.
2. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. (2017). Environmental Engineering. McGraw-Hill Education.
3. Trivedi, R.K. and Goel, P.K. (2019). Introduction to Air Pollution. Environmental Publications.
4. Cunningham, W.P. and Cunningham, M.A. (2020). Environmental Science: A Global Concern. McGraw-Hill Education.
5. Sharma, B.K. (2021). Environmental Chemistry. Goel Publishing House.
6. De, A.K. (2017). Environmental Chemistry. New Age International Publishers.
7. Manahan, S.E. (2017). Fundamentals of Environmental Chemistry. CRC Press.
8. Bharucha, E. (2019). Textbook of Environmental Studies. Universities Press.
9. Arceivala, S.J. and Asolekar, S.R. (2013). Wastewater Treatment for Pollution Control. McGraw-Hill Education.
10. Reddy, M.A. (2016). Textbook of Environmental Science and Technology. BSP Publications.
11. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India – Environmental Regulations and Reports.
12. Central Pollution Control Board (CPCB) Manuals and Guidelines.
13. APHA (2023). Standard Methods for the Examination of Water and Wastewater.

14. UNEP Global Environment Reports.
15. World Health Organization (WHO) Reports on Environmental Health.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                                    |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Explain the definitions, concepts, types, causes, and classification of pollutants including primary and secondary pollutants and their environmental significance.      |
| <b>CO2</b>    | Identify major air pollutants—PM2.5, PM10, SO <sub>2</sub> , NO <sub>x</sub> , CO, ozone, and greenhouse gases—and analyze their sources, effects, and control measures. |
| <b>CO3</b>    | Analyze the causes, types, and environmental effects of water pollution including eutrophication, waterborne diseases, and surface and groundwater contamination.        |
| <b>CO4</b>    | Understand the physical, chemical, and biological characteristics of water pollution and evaluate wastewater treatment methods from primary to tertiary levels.          |
| <b>CO5</b>    | Describe soil pollution, noise pollution, and thermal pollution—their sources, impacts on ecosystems and human health, and remediation methods.                          |
| <b>CO6</b>    | Analyze the management of solid waste, hazardous waste, biomedical waste, e-waste, and radioactive waste using appropriate disposal and treatment strategies.            |
| <b>CO7</b>    | Understand pollution monitoring techniques, environmental quality standards, and the application of the Air Quality Index (AQI) in environmental assessment.             |
| <b>CO8</b>    | Evaluate pollution prevention, control, and remediation strategies including the principles of reduce, reuse, recycle, recovery, and circular economy.                   |
| <b>CO9</b>    | Apply knowledge of environmental regulations, pollution control boards, and sustainable practices to minimize environmental impacts.                                     |
| <b>CO10</b>   | Develop critical awareness of emerging issues such as microplastics, single-use plastics, and green technologies for pollution control.                                  |

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO6       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 3    |
| CO9       | 2   | 3   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 2    |
| CO10      | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

**Code: ENVIRONMENTAL POLLUTION LAB  
(Practical)**

**Credits: 4**

### **COURSE OBJECTIVES**

- To provide hands-on training in the analysis and monitoring of environmental pollutants.
- To familiarize students with standard methods used for assessing air, water, soil, and noise pollution.
- To develop skills in environmental sample collection, analysis, interpretation, and reporting.
- To understand environmental quality standards and pollution control measures.

### **LIST OF EXPERIMENTS**

#### **UNIT I. WATER POLLUTION ANALYSIS**

1. Estimation of pH by pH meter.
2. Estimation of Electrical Conductivity (EC) by conductivity meter.
3. Estimation of Turbidity by nephelometric method.
4. Estimation of Total Dissolved Solids (TDS) by gravimetric method.
5. Estimation of Dissolved Oxygen (DO) by Winkler's method.
6. Estimation of Total Hardness by EDTA titrimetric method.
7. Estimation of Chloride by argentometric method.

#### **UNIT II. SOIL POLLUTION ANALYSIS**

8. Determination of soil pH.
9. Determination of soil electrical conductivity.
10. Estimation of soil organic carbon/organic matter.
11. Determination of available phosphorus in soil.

#### **UNIT III. AIR AND NOISE POLLUTION ANALYSIS**

12. Measurement of ambient particulate matter (demonstration).
13. Demonstration of ambient sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) monitoring.
14. Measurement of ambient noise levels using sound level meter.

#### **UNIT IV. SOLID WASTE AND ENVIRONMENTAL MONITORING**

15. Characterization and segregation of municipal solid waste.
16. Identification and classification of biodegradable and non-biodegradable wastes.
17. Field visit to a wastewater treatment plant, solid waste management facility, pollution control laboratory, or recycling unit and submission of a report.

### **REFERENCES**

1. Trivedi, R.K. and Goel, P.K. Chemical and Biological Methods for Water Pollution Studies. Environmental Publications,

- Karad, 1984.
2. APHA. Standard Methods for the Examination of Water and Wastewater. APHA–AWWA–WEF, Latest Edition.
  3. Sawyer, C.N. and McCarty, P.L. Chemistry for Environmental Engineering. McGraw Hill International, 1978.
  4. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. Environmental Engineering. McGraw-Hill Education, 2017.
  5. Rao, C.S. Environmental Pollution Control Engineering. New Age International Publishers, 2018.
  6. Margesin, R. and Schinner, F. Manual of Soil Analysis. Springer, 2005.
  7. Central Pollution Control Board (CPCB) Laboratory Manuals and Guidelines.
  8. Ministry of Environment, Forest and Climate Change (MoEFCC) Environmental Monitoring Guidelines.
  9. APHA Water Analysis Manuals and WHO Water Quality Guidelines.
  10. UNEP and WHO Environmental Monitoring Reports.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                    |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Collect, handle, and preserve environmental samples—water, soil, air—following standard scientific procedures and safety protocols.                      |
| <b>CO2</b>    | Estimate key physico-chemical parameters of water including pH, electrical conductivity, turbidity, TDS, dissolved oxygen, total hardness, and chloride. |
| <b>CO3</b>    | Analyze soil quality parameters including pH, electrical conductivity, organic carbon, organic matter, and available phosphorus using standard methods.  |
| <b>CO4</b>    | Measure and interpret ambient air quality and noise pollution levels using appropriate monitoring instruments and standard methods.                      |
| <b>CO5</b>    | Identify and classify municipal solid waste into biodegradable and non-biodegradable categories and explain appropriate disposal practices.              |
| <b>CO6</b>    | Compare analytical results with national and international environmental quality standards set by CPCB, WHO, and other regulatory bodies.                |
| <b>CO7</b>    | Develop skills in environmental data recording, interpretation, and scientific report writing for pollution assessment studies.                          |
| <b>CO8</b>    | Recommend suitable pollution prevention and control measures based on laboratory findings and environmental quality data.                                |
| <b>CO9</b>    | Conduct field visits to pollution control facilities—wastewater treatment plants, solid waste management sites—and prepare detailed visit reports.       |
| <b>CO10</b>   | Apply laboratory findings to understand real-world                                                                                                       |

|  |                                                                                                        |
|--|--------------------------------------------------------------------------------------------------------|
|  | environmental pollution scenarios and develop critical problem-solving skills in pollution management. |
|--|--------------------------------------------------------------------------------------------------------|

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 1   | 1   | 3   | 2   | 2   | 2   | 2   | 1    |
| CO2       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO3       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO4       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 1    |
| CO5       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2    |
| CO7       | 2   | 2   | 3   | 3   | 2   | 3   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 2   | 3    |
| CO9       | 3   | 2   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO10      | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 2   | 3    |

**Code: ENVIRONMENTAL MICROBIOLOGY**  
**(Theory)**

**Credits: 4**

### **COURSE OBJECTIVES**

- To understand the diversity, structure, and functions of microorganisms in the environment.
- To study the role of microorganisms in ecosystem processes and nutrient cycling.
- To understand the significance of microorganisms in environmental pollution and public health.
- To introduce the applications of microorganisms in environmental management and sustainable development.
- To develop knowledge on microbial technologies used in waste treatment and bioremediation.

### **UNIT – I: INTRODUCTION TO ENVIRONMENTAL MICROBIOLOGY**

History, scope, and importance of environmental microbiology; Classification of microorganisms; General characteristics of bacteria, fungi, algae, protozoa, and viruses; Structure of prokaryotic and eukaryotic cells; Growth and reproduction of microorganisms; Beneficial and harmful microorganisms.

### **UNIT – II: MICROBIAL ECOLOGY**

Distribution of microorganisms in soil, water, and air; Factors influencing microbial growth and distribution; Microbial interactions – mutualism, commensalism, parasitism, competition, and predation; Rhizosphere microorganisms and plant-microbe interactions; Role of microorganisms in ecosystem functioning.

### **UNIT – III: MICROORGANISMS IN BIOGEOCHEMICAL CYCLES**

Role of microorganisms in nutrient cycling; Carbon cycle and decomposition; Nitrogen cycle – nitrogen fixation, ammonification, nitrification, and denitrification; Phosphorus and sulfur cycles; Microbial contribution to soil fertility and ecosystem productivity.

### **UNIT – IV: ENVIRONMENTAL HEALTH AND MICROBIAL POLLUTION**

Airborne microorganisms and bioaerosols; Waterborne and foodborne diseases; Microbial contamination of air, water, and soil; Indicator microorganisms of environmental pollution; Assessment of microbiological quality of water; Most Probable Number (MPN) technique and Biological Oxygen Demand (BOD); Public health significance of environmental microorganisms.

## **UNIT – V: APPLIED ENVIRONMENTAL MICROBIOLOGY**

Wastewater treatment – aerobic and anaerobic processes; Activated sludge process and biogas production; Bioremediation of contaminated environments; Biofertilizers and biopesticides; Composting and vermicomposting; Microbial applications in solid waste management and sustainable agriculture.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Microplastics and Microbial Degradation; Environmental DNA (eDNA) and Biodiversity Monitoring; Emerging Waterborne Diseases; Microbial Solutions for Climate Change Mitigation; Biofertilizers for Sustainable Agriculture; Circular Bioeconomy and Waste-to-Resource Technologies.

## **REFERENCES**

1. Atlas, R.M. and Bartha, R. (2011). Microbial Ecology: Fundamentals and Applications. Benjamin Cummings Publishing.
2. Pepper, I.L., Gerba, C.P. and Gentry, T.J. (2015). Environmental Microbiology. Academic Press.
3. Maier, R.M., Pepper, I.L. and Gerba, C.P. (2009). Environmental Microbiology. Elsevier Academic Press.
4. Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. (2011). Microbiology: Concepts and Applications. McGraw-Hill Education.
5. Bitton, G. (2020). Wastewater Microbiology. Wiley Publications.
6. Murugesan, A.G. and Rajakumari, C. (2006). Environmental Science and Biotechnology. MJP Publishers.
7. Jemba, P.K. (2004). Environmental Microbiology. Science Publishers.
8. Srivastava, M.L. (2003). Basic Environmental Microbiology. Manohar Publishers.
9. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
10. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environment and Resource Conservation. Anamaya Publishers.
11. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M. and Stahl, D.A. (2021). Brock Biology of Microorganisms. Pearson Education.
12. Tortora, G.J., Funke, B.R. and Case, C.L. (2020). Microbiology: An Introduction. Pearson Education.

## **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                        |
|---------------|--------------------------------------------------------------------------------------------------------------|
| CO1           | Describe the classification, structural characteristics, and functions of major environmental microorganisms |

|             |                                                                                                                                                                       |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | including bacteria, fungi, algae, protozoa, and viruses.                                                                                                              |
| <b>CO2</b>  | Explain the distribution of microorganisms in soil, water, and air, and identify the factors influencing their growth, distribution, and ecological roles.            |
| <b>CO3</b>  | Analyze microbial interactions—mutualism, commensalism, parasitism, competition, and predation—and explain plant-microbe interactions in the rhizosphere.             |
| <b>CO4</b>  | Describe the role of microorganisms in major biogeochemical cycles—carbon, nitrogen, phosphorus, and sulfur cycles—and their contribution to ecosystem productivity.  |
| <b>CO5</b>  | Identify major microbial pollutants, waterborne and foodborne pathogens, and bioaerosols, and assess their significance for environmental and public health.          |
| <b>CO6</b>  | Apply microbiological techniques including MPN method, BOD analysis, and water quality assessment to evaluate the microbiological quality of environmental samples.   |
| <b>CO7</b>  | Understand the principles of aerobic and anaerobic wastewater treatment, activated sludge processes, and biogas production for sustainable waste management.          |
| <b>CO8</b>  | Evaluate the applications of bioremediation, biofertilizers, biopesticides, composting, and vermicomposting in environmental management and sustainable agriculture.  |
| <b>CO9</b>  | Analyze emerging trends in environmental microbiology including microbial degradation of microplastics, environmental DNA (eDNA), and circular bioeconomy approaches. |
| <b>CO10</b> | Develop awareness of microbial technologies for climate change mitigation and sustainable resource management in environmental science.                               |

### CO-PO Mapping

Mapping Level: 3 = High Correlation | 2 = Medium Correlation  
| 1 = Low Correlation

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO4       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO6       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO8       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 3    |
| CO9       | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO10      | 2   | 3   | 2   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

Code:

**BIostatISTICS AND COMPUTATION**  
(Theory)

Credits: 4

**COURSE OBJECTIVES**

- To introduce the fundamental concepts and applications of biostatistics in environmental sciences.
- To develop skills in collection, organization, analysis, and interpretation of environmental data.
- To understand probability distributions and statistical methods used in ecological and environmental studies.
- To familiarize students with computer applications and statistical software for environmental data analysis.
- To provide a foundation for research methodology and scientific reporting.

**UNIT – I: INTRODUCTION TO BIostatISTICS**

Biostatistics: Definition, scope, and importance; Types of data; Collection and classification of data; Sampling methods; Frequency distribution; Tabulation and graphical representation of data – bar diagrams, histograms, pie charts, frequency polygons, and ogives.

**UNIT – II: DESCRIPTIVE STATISTICS**

Measures of central tendency – mean, median, and mode; Measures of dispersion – range, variance, standard deviation, and coefficient of variation; Skewness and kurtosis; Data interpretation and presentation in environmental studies.

**UNIT – III: PROBABILITY AND STATISTICAL INFERENCE**

Basic concepts of probability; Probability distributions – binomial, Poisson, and normal distributions; Sampling distribution; Standard error; Confidence intervals; Introduction to hypothesis testing; Errors in statistical testing.

**UNIT – IV: STATISTICAL TESTS AND CORRELATION**

Tests of significance – t-test, Chi-square test, and Analysis of Variance (ANOVA); Correlation and regression analysis; Interpretation of statistical outputs; Applications of statistical methods in ecology and environmental science.

**UNIT – V: COMPUTATION AND DATA ANALYSIS**

Introduction to computers and data management; Spreadsheet applications using MS Excel/Open-source software; Data entry, sorting, filtering, and graphical presentation; Statistical analysis using spreadsheet tools; Introduction to statistical software packages (R, PSPP, SPSS, or equivalent open-source software); Applications in environmental monitoring and biodiversity

assessment.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Big Data in Environmental Science; Artificial Intelligence and Environmental Analytics; Data Visualization Techniques; Citizen Science and Environmental Data; Open-Source Statistical Software; Environmental Modelling and Decision Support Systems.

### **REFERENCES**

1. Zar, J.H. (2010). Biostatistical Analysis. Pearson Education.
2. Daniel, W.W. and Cross, C.L. (2018). Biostatistics: A Foundation for Analysis in the Health Sciences. Wiley.
3. Sokal, R.R. and Rohlf, F.J. (2012). Biometry. W.H. Freeman and Company.
4. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Applied Statistics. Sultan Chand & Sons.
5. Sundararajan, N., Balaji, R. and Kalaivani, K. (2017). Biostatistics. MJP Publishers.
6. Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. Wiley.
7. Pagano, M. and Gauvreau, K. (2018). Principles of Biostatistics. CRC Press.
8. Triola, M.F. (2022). Elementary Statistics. Pearson Education.
9. Elmasri, R. and Navathe, S.B. (2016). Fundamentals of Database Systems. Pearson.
10. Microsoft Excel Documentation and Tutorials.
11. R Core Team. Introduction to R for Statistical Computing.
12. Kothari, C.R. (2004). Research Methodology: Methods and Techniques. New Age International Publishers.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Understand the scope and importance of biostatistics in environmental science and differentiate types of data, sampling methods, and data classification.   |
| <b>CO2</b>    | Collect, organize, and present environmental data using appropriate graphical representations—bar diagrams, histograms, pie charts, and frequency polygons. |
| <b>CO3</b>    | Calculate and interpret measures of central tendency—mean, median, mode—and measures of dispersion—range, variance, standard deviation, CV.                 |
| <b>CO4</b>    | Apply concepts of probability and statistical distributions—binomial, Poisson, and normal—to environmental data sets and ecological studies.                |
| <b>CO5</b>    | Understand the principles of sampling distributions, standard error, confidence intervals, and hypothesis testing including Type I and Type II errors.      |
| <b>CO6</b>    | Perform and interpret tests of significance including t-                                                                                                    |

|             |                                                                                                                                                        |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | test, Chi-square test, and ANOVA for environmental and ecological datasets.                                                                            |
| <b>CO7</b>  | Apply correlation and regression analysis to establish relationships between environmental variables and interpret statistical outputs.                |
| <b>CO8</b>  | Use spreadsheet tools such as MS Excel or open-source equivalents for data entry, sorting, graphical presentation, and basic statistical computations. |
| <b>CO9</b>  | Apply statistical software packages—R, PSPP, or equivalent—for advanced environmental data analysis, biodiversity assessment, and modeling.            |
| <b>CO10</b> | Analyze and communicate scientific data effectively in environmental research reports, supporting evidence-based decision-making.                      |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO8       | 1   | 2   | 2   | 2   | 3   | 3   | 2   | 3   | 2   | 2    |
| CO9       | 1   | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2    |
| CO10      | 3   | 3   | 3   | 3   | 2   | 3   | 2   | 3   | 3   | 3    |

**Code: ENVIRONMENTAL TOOLS AND TECHNIQUES Credits: 4**  
**(Theory)**

### **COURSE OBJECTIVES**

- To introduce the fundamental tools and techniques used in environmental studies and research.
- To provide knowledge on environmental monitoring, assessment, and data collection methods.
- To familiarize students with modern geospatial technologies such as Remote Sensing and Geographic Information Systems (GIS).
- To develop skills in environmental data analysis, interpretation, and decision-making.
- To understand the applications of environmental tools in resource management, pollution monitoring, and biodiversity conservation.

### **UNIT – I: ENVIRONMENTAL MONITORING AND SAMPLING TECHNIQUES**

Environmental monitoring: Concept, objectives, and importance; Environmental quality standards; Sampling techniques for air, water, soil, and biological samples; Sample collection, preservation, transportation, and storage; Environmental data collection and field survey methods; Introduction to environmental instrumentation.

### **UNIT – II: ENVIRONMENTAL ANALYTICAL TECHNIQUES**

Physical, chemical, and biological analysis of environmental samples; Measurement of pH, conductivity, dissolved oxygen, turbidity, and particulate matter; Spectrophotometry and colorimetry; Chromatographic techniques – principles and applications; Bioindicators and biomonitoring; Environmental data interpretation.

### **UNIT – III: REMOTE SENSING**

Principles of Remote Sensing; Electromagnetic spectrum and energy interactions; Platforms and sensors; Types of Remote Sensing – passive and active remote sensing; Satellite systems and applications; Image interpretation elements; Applications of Remote Sensing in land use and land cover mapping, agriculture, forestry, water resources, biodiversity assessment, disaster management, and climate studies.

### **UNIT – IV: GEOGRAPHIC INFORMATION SYSTEM (GIS)**

Introduction to GIS; Components of GIS; Spatial and attribute data; Data input, storage, retrieval, and analysis; Vector and raster data models; Map projections and coordinate systems; GIS

database management; Applications of GIS in environmental management and planning.

## **UNIT – V: ENVIRONMENTAL IMPACT ASSESSMENT AND DECISION SUPPORT TOOLS**

Environmental Impact Assessment (EIA): Concepts, objectives, and procedures; Screening, scoping, impact prediction, and mitigation measures; Environmental auditing; Risk assessment and environmental management plans; Decision support systems; Applications of GIS and Remote Sensing in EIA and environmental planning.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Artificial Intelligence in Environmental Monitoring; Drone-Based Environmental Surveys; Geographic Information Systems for Smart Cities; Internet of Things (IoT) in Environmental Monitoring; Environmental Big Data Analytics; Open-Source GIS Platforms (QGIS); Climate Change Monitoring Using Satellite Data.

## **REFERENCES**

1. Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2015). Remote Sensing and Image Interpretation. Wiley.
2. Campbell, J.B. and Wynne, R.H. (2011). Introduction to Remote Sensing. Guilford Press.
3. Burrough, P.A. and McDonnell, R.A. (2015). Principles of Geographical Information Systems. Oxford University Press.
4. Chang, K.T. (2021). Introduction to Geographic Information Systems. McGraw-Hill Education.
5. Lo, C.P. and Yeung, A.K.W. (2016). Concepts and Techniques of Geographic Information Systems. Pearson Education.
6. Jensen, J.R. (2016). Introductory Digital Image Processing: A Remote Sensing Perspective. Pearson.
7. Rao, C.S. (2018). Environmental Pollution Control Engineering. New Age International Publishers.
8. Trivedi, R.K. and Goel, P.K. Practical Methods in Ecology and Environmental Science. Environmental Publications.
9. Manahan, S.E. (2017). Environmental Chemistry. CRC Press.
10. Weng, Q. (2010). Remote Sensing and GIS Integration: Theories, Methods and Applications. McGraw-Hill.
11. United Nations Environment Programme (UNEP) Environmental Assessment Manuals.
12. QGIS Documentation and Open-Source GIS Training Materials.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                           |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the objectives, principles, and importance of environmental monitoring and explain the sampling techniques used for air, water, soil, and biological samples. |
| <b>CO2</b>  | Apply physical, chemical, and biological analytical techniques—spectrophotometry, chromatography, colorimetry—for environmental quality assessment.                      |
| <b>CO3</b>  | Explain the principles of Remote Sensing, the electromagnetic spectrum, energy interactions, and the classification of platforms and sensors.                            |
| <b>CO4</b>  | Apply remote sensing data and satellite imagery for land use and land cover mapping, agriculture, forestry, water resource, and biodiversity assessment.                 |
| <b>CO5</b>  | Describe the components of GIS, spatial and attribute data types, data input methods, and vector and raster data models for environmental mapping.                       |
| <b>CO6</b>  | Apply GIS tools for environmental management, planning, spatial analysis, and data-driven decision-making in resource management.                                        |
| <b>CO7</b>  | Understand the concepts, objectives, and procedural steps of Environmental Impact Assessment including screening, scoping, prediction, and mitigation.                   |
| <b>CO8</b>  | Evaluate environmental auditing, risk assessment, and environmental management plans and their role in sustainable environmental governance.                             |
| <b>CO9</b>  | Apply integrated geospatial tools—GIS and Remote Sensing—for Environmental Impact Assessment and sustainable environmental planning.                                     |
| <b>CO10</b> | Analyze emerging technologies including AI, drones, IoT, and open-source GIS platforms for next-generation environmental monitoring and decision support.                |

## CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO2       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 1   | 2    |
| CO4       | 1   | 3   | 3   | 2   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 1   | 2    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO9       | 1   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 2    |
| CO10      | 2   | 3   | 3   | 2   | 3   | 3   | 3   | 2   | 2   | 3    |

**Code: ENVIRONMENTAL LAW AND TECHNIQUES**  
**(Theory)**

**Credits: 4**

### **COURSE OBJECTIVES**

- To provide an understanding of environmental laws, policies, and governance mechanisms.
- To familiarize students with national and international environmental regulations.
- To introduce environmental management and assessment techniques used in environmental protection.
- To develop awareness of environmental rights, responsibilities, and legal compliance.
- To understand the application of modern environmental monitoring and management tools.

### **UNIT – I: INTRODUCTION TO ENVIRONMENTAL LAW**

Concept and scope of Environmental Law; Evolution of environmental legislation; Environmental ethics and environmental justice; Constitutional provisions related to environmental protection in India; Fundamental Rights, Fundamental Duties, and Directive Principles of State Policy; Environmental governance and sustainable development.

### **UNIT – II: NATIONAL ENVIRONMENTAL LEGISLATIONS**

Water (Prevention and Control of Pollution) Act, 1974; Air (Prevention and Control of Pollution) Act, 1981; Environment (Protection) Act, 1986; Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980; Biological Diversity Act, 2002; National Green Tribunal (NGT) Act, 2010; Roles and functions of CPCB and SPCBs.

### **UNIT – III: INTERNATIONAL ENVIRONMENTAL AGREEMENTS**

International environmental governance; Stockholm Conference (1972); Rio Earth Summit (1992); Agenda 21; Convention on Biological Diversity (CBD); Ramsar Convention; Convention on International Trade in Endangered Species (CITES); Montreal Protocol; Kyoto Protocol; Paris Agreement on Climate Change; Sustainable Development Goals (SDGs).

### **UNIT – IV: ENVIRONMENTAL IMPACT ASSESSMENT AND AUDIT**

Environmental Impact Assessment (EIA): Concept, objectives, process, and significance; Environmental Clearance Procedures; Environmental Management Plan (EMP); Environmental Auditing; Environmental Risk Assessment; Public participation in environmental decision-making; Case studies of EIA in India.

## **UNIT – V: ENVIRONMENTAL MONITORING AND MANAGEMENT TECHNIQUES**

Environmental Monitoring: Air, water, soil, and noise quality monitoring; Environmental Quality Standards; Geographic Information Systems (GIS) and Remote Sensing applications in environmental management; Environmental Information Systems; Waste management techniques; Cleaner production and pollution prevention technologies.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

National Green Tribunal Judgements; Environmental Litigation in India; Climate Change Laws and Policies; ESG (Environmental, Social and Governance) Frameworks; Green Technologies; Carbon Credits and Carbon Trading; Environmental Compliance and Corporate Responsibility.

## **REFERENCES**

1. Divan, S. and Rosencranz, A. (2022). Environmental Law and Policy in India. Oxford University Press.
2. Shastri, S.C. (2021). Environmental Law. Eastern Book Company.
3. P. Leelakrishnan (2019). Environmental Law in India. LexisNexis Publications.
4. Ball, S. and Bell, S. (2018). Environmental Law. Oxford University Press.
5. Benny Joseph (2017). Environmental Studies. McGraw-Hill Education.
6. Uberoi, N.K. (2018). Environmental Management. Excel Books.
7. Bharucha, E. (2019). Textbook of Environmental Studies. Universities Press.
8. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India Publications.
9. Central Pollution Control Board (CPCB) Manuals and Guidelines.
10. National Green Tribunal (NGT) Reports and Case Documents.
11. UNEP Environmental Governance Reports.
12. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environment and Resource Conservation. Anamaya Publishers.

## **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                    |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Explain the concept, scope, and evolution of environmental law, and describe constitutional provisions and environmental governance frameworks in India. |
| <b>CO2</b>    | Describe the major national environmental                                                                                                                |

|             |                                                                                                                                                                              |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | legislations—Water Act 1974, Air Act 1981, EPA 1986, Wildlife Act, Forest Act, Biological Diversity Act—and their significance.                                              |
| <b>CO3</b>  | Explain the roles and functions of regulatory bodies including CPCB, SPCBs, and the National Green Tribunal in environmental protection.                                     |
| <b>CO4</b>  | Analyze major international environmental agreements including Stockholm Conference, Rio Summit, CBD, Ramsar, CITES, Montreal Protocol, Kyoto Protocol, and Paris Agreement. |
| <b>CO5</b>  | Understand the concepts, objectives, and procedural steps of Environmental Impact Assessment and its role in environmental clearance processes in India.                     |
| <b>CO6</b>  | Evaluate Environmental Auditing, Environmental Risk Assessment, Environmental Management Plans, and the importance of public participation in decision-making.               |
| <b>CO7</b>  | Apply environmental monitoring techniques—air, water, soil, and noise—and understand environmental quality standards for compliance and management.                          |
| <b>CO8</b>  | Use GIS and Remote Sensing applications in environmental law enforcement, monitoring, and sustainable environmental planning.                                                |
| <b>CO9</b>  | Evaluate environmental legal issues, case studies from the NGT, ESG frameworks, carbon credits, and corporate environmental compliance.                                      |
| <b>CO10</b> | Develop critical perspectives on environmental justice, climate change laws, rights-based approaches to environment, and sustainable environmental governance.               |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO4       | 2   | 3   | 3   | 3   | 2   | 3   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO6       | 1   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2    |
| CO9       | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO10      | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |

**Code: ENVIRONMENTAL MICROBIOLOGY  
(Practical)**

**Credits: 4**

### **COURSE OBJECTIVES:**

Upon completion of this practical course, students will be able to:

- Understand basic microbiology techniques including laboratory safety, microscopy, sterilization, and culture media preparation.
- Isolate and observe bacteria and fungi from soil and other environmental samples using standard laboratory methods.
- Perform and interpret different staining and biochemical tests for the identification and characterization of microorganisms.
- Assess microbial quality of water using methods such as the Most Probable Number (MPN) technique and antibiotic sensitivity testing.
- Develop practical skills in environmental microbiology through microbial identification, observation, recording of results, and proper laboratory practices.

### **EXPERIMENTS**

1. Introduction to General Microbiology: Laboratory Rules, Microscopy,
2. Sterilization, Preparation of Culture Media, Isolation of Bacteria from Soil,
3. Isolation of fungi from Soil, Ubiquitous nature of Microorganisms.
4. Types of staining techniques: Simple staining, Gram staining, Capsular staining and Endospore staining.
5. Demonstration of motility for bacteria by hanging drop technique
6. List of Biochemical Test: Indole production, Methyl Red, Voges Proskauer,
7. Citrate Utilization, Triple sugar-Iron agar, Catalase and Oxidase Test
8. Antibiotic sensitivity test: Disc diffusion method
9. Most Probable Number (MPN): Presumptive, Confirmatory and complete test
10. Identification of Fungi: Lacto phenol cotton blue test

### **REFERENCES:**

1. Willey. Prescott's Microbiology. New York: McGraw-Hill, 2011.

### **COURSE OUTCOMES:**

Upon successful completion of the course, students will be able

to:

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                                    |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Demonstrate proper laboratory safety practices, microscopy skills, and understanding of microbial diversity encountered in environmental samples.                        |
| <b>CO2</b>    | Perform sterilization procedures, prepare culture media, and isolate bacteria and fungi from soil and environmental sources.                                             |
| <b>CO3</b>    | Identify the ubiquitous nature of microorganisms in different environmental matrices through controlled laboratory experiments.                                          |
| <b>CO4</b>    | Apply staining techniques—simple, Gram, capsular, and endospore staining—to characterize and differentiate bacterial species.                                            |
| <b>CO5</b>    | Demonstrate bacterial motility using hanging drop technique and relate motility to ecological adaptations of microorganisms.                                             |
| <b>CO6</b>    | Perform a series of biochemical tests including indole, methyl red, Voges–Proskauer, citrate utilization, TSI, catalase, and oxidase tests for microbial identification. |
| <b>CO7</b>    | Conduct antibiotic sensitivity testing using the disc diffusion method and interpret results in relation to environmental health implications.                           |
| <b>CO8</b>    | Execute the MPN technique including presumptive, confirmatory, and complete tests for microbiological water quality assessment.                                          |
| <b>CO9</b>    | Identify fungi using lactophenol cotton blue staining and relate fungal diversity to ecological decomposition and soil health.                                           |
| <b>CO10</b>   | Develop laboratory competency to safely and effectively perform routine microbial culture, isolation, identification, and characterization procedures.                   |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 1   | 1   | 2   | 2   | 2   | 1   | 1   | 1    |
| CO2       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO3       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO4       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO9       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO10      | 1   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 2    |

Code:

**ENVIRONMENTAL TOXICOLOGY**  
**(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To introduce the fundamental principles and concepts of environmental toxicology.
- To understand the sources, transport, fate, and effects of environmental toxicants.
- To study the impact of toxic substances on ecosystems, wildlife, and human health.
- To familiarize students with toxicity testing and environmental risk assessment.
- To develop awareness of toxic pollutants and their management for environmental protection.

**UNIT – I: FUNDAMENTALS OF TOXICOLOGY**

Introduction to Toxicology: Definition, scope, and importance; Principles of toxicology; Toxicants and toxins; Sources of environmental toxicants; Exposure pathways and routes of entry (inhalation, ingestion, dermal absorption); Dose-response relationship; Concepts of LD<sub>50</sub>, LC<sub>50</sub>, and ED<sub>50</sub>; Acute and chronic toxicity; Factors influencing toxicity.

**UNIT – II: ENVIRONMENTAL FATE OF TOXICANTS**

Sources and distribution of toxic substances in air, water, soil, and food; Environmental transport and transformation of pollutants; Bioaccumulation, biomagnification, and biotransformation; Persistence of toxic chemicals in ecosystems; Toxic pollutants in food chains and food webs.

**UNIT – III: MAJOR ENVIRONMENTAL TOXICANTS**

Heavy metals (lead, mercury, cadmium, arsenic); Pesticides and agrochemicals; Industrial pollutants; Persistent Organic Pollutants (POPs); Plastics and microplastics; Emerging contaminants including pharmaceuticals and personal care products; Sources, environmental behavior, and impacts.

**UNIT – IV: ECOTOXICOLOGY AND TOXICITY ASSESSMENT**

Concept of ecotoxicology; Effects of toxicants on plants, animals, and microorganisms; Toxicity testing and bioassays; Biomarkers and bioindicators; Principles of environmental risk assessment; Threshold Limit Value (TLV) and safety standards; Applications and limitations of toxicity assessment methods.

**UNIT – V: HUMAN HEALTH AND TOXIC EFFECTS**

Health effects of environmental pollutants; Organ toxicity – hepatotoxicity, nephrotoxicity, neurotoxicity, pulmonary toxicity,

and reproductive toxicity; Carcinogenicity, mutagenicity, and teratogenicity; Occupational exposure to toxic substances; Prevention and management of toxic exposures.

### **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Microplastics and Human Health; Endocrine Disrupting Chemicals (EDCs); PFAS ("Forever Chemicals"); Electronic Waste Toxicity; Environmental Health Risk Assessment; Industrial Toxic Disasters; Climate Change and Toxic Pollutant Dynamics; Recent Case Studies from India and Abroad.

### **REFERENCES**

1. Klaassen, C.D. (2021). Casarett and Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill Education.
2. Roberts, S.M., James, R.C. and Williams, P.L. (2015). Principles of Toxicology: Environmental and Industrial Applications. John Wiley & Sons.
3. Shaw, I.C. and Chadwick, J. (1998). Principles of Environmental Toxicology. CRC Press.
4. Sparling, D.W. (2017). Basics of Ecotoxicology. CRC Press.
5. Walker, C.H., Sibly, R.M., Hopkin, S.P. and Peakall, D.B. (2012). Principles of Ecotoxicology. CRC Press.
6. Kaiden Higgins (2017). Environmental Toxicology. Larsen and Keller Education.
7. Manahan, S.E. (2017). Environmental Chemistry. CRC Press.
8. De, A.K. (2017). Environmental Chemistry. New Age International Publishers.
9. Cunningham, W.P. and Cunningham, M.A. (2020). Environmental Science: A Global Concern. McGraw-Hill Education.
10. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
11. World Health Organization (WHO) Reports on Environmental Health.
12. United Nations Environment Programme (UNEP) Publications on Chemicals and Waste.
13. Central Pollution Control Board (CPCB) Reports and Guidelines.
14. Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles.
15. Environmental Protection Agency (EPA) Toxicity Assessment Manuals.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                                         |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Explain the fundamental principles of toxicology including dose-response relationships, LD50, LC50, ED50, and the distinction between acute and chronic toxicity.                      |
| <b>CO2</b>  | Describe the sources, exposure pathways—inhalation, ingestion, dermal absorption—and routes of entry of environmental toxicants into organisms.                                        |
| <b>CO3</b>  | Analyze the environmental transport, transformation, bioaccumulation, biomagnification, and persistence of toxic chemicals in ecosystems and food chains.                              |
| <b>CO4</b>  | Identify and describe major classes of environmental toxicants—heavy metals, pesticides, POPs, microplastics, and emerging contaminants—and their sources and behaviors.               |
| <b>CO5</b>  | Explain the concepts of ecotoxicology and evaluate the effects of toxicants on plants, animals, and microorganisms in terrestrial and aquatic ecosystems.                              |
| <b>CO6</b>  | Apply toxicity testing methods, bioassays, biomarkers, and bioindicators for environmental toxicity assessment and interpretation.                                                     |
| <b>CO7</b>  | Understand the principles of environmental risk assessment, Threshold Limit Values (TLV), and safety standards for toxic substances.                                                   |
| <b>CO8</b>  | Analyze the human health effects of environmental pollutants including organ toxicity—hepatotoxicity, nephrotoxicity, neurotoxicity—carcinogenicity, mutagenicity, and teratogenicity. |
| <b>CO9</b>  | Evaluate strategies for prevention and management of toxic exposures in occupational and environmental settings.                                                                       |
| <b>CO10</b> | Interpret contemporary toxicological issues such as microplastics, endocrine disrupting chemicals, PFAS, e-waste toxicity, and industrial toxic disasters.                             |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO5       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 2    |
| CO9       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO10      | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

**Code: CLIMATE CHANGE AND SUSTAINABILITY  
(Theory)**

**Credits: 4**

### **COURSE OBJECTIVES**

- To provide a comprehensive understanding of climate change, its causes, impacts, and mitigation strategies.
- To understand the scientific basis of climate change and its influence on natural and human systems.
- To examine the concepts and principles of sustainability and sustainable development.
- To familiarize students with climate change adaptation, resilience, and policy frameworks.
- To develop awareness of sustainable practices for environmental conservation and resource management.

### **UNIT – I: INTRODUCTION TO CLIMATE CHANGE**

Weather and Climate: Concepts and differences; Climate system and its components; Greenhouse effect and greenhouse gases; Causes of climate change – natural and anthropogenic factors; Evidence of climate change; Global warming and climate variability; Overview of climate science and climate modeling.

### **UNIT – II: IMPACTS OF CLIMATE CHANGE**

Climate change impacts on atmosphere, hydrosphere, lithosphere, and biosphere; Effects on ecosystems and biodiversity; Impacts on agriculture, water resources, forests, fisheries, and human health; Extreme weather events – floods, droughts, heat waves, cyclones, and sea-level rise; Vulnerability and risk assessment.

### **UNIT – III: CLIMATE CHANGE MITIGATION**

Mitigation: Concepts and approaches; Reduction of greenhouse gas emissions; Renewable energy technologies; Energy efficiency and conservation; Carbon sequestration and carbon capture; Sustainable transportation; Green buildings and low-carbon development; Nature-based solutions for climate mitigation.

### **UNIT – IV: CLIMATE CHANGE ADAPTATION AND RESILIENCE**

Adaptation to climate change: Concepts and strategies; Climate-resilient agriculture; Water resource adaptation measures; Disaster risk reduction and climate resilience; Community-based adaptation; Ecosystem-based adaptation; Climate-smart development practices.

### **UNIT – V: SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT**

Concept and principles of sustainability; Sustainable Development Goals (SDGs); Environmental, social, and economic

dimensions of sustainability; Circular economy; Sustainable consumption and production; Ecological footprint and carbon footprint; Corporate sustainability and Environmental, Social and Governance (ESG) principles; Sustainable lifestyles and green technologies.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Global Climate Agreements and COP Summits; Paris Agreement and Net-Zero Emissions; Climate Justice and Equity; Climate Finance and Carbon Markets; Loss and Damage Fund; Youth and Climate Action; Sustainable Cities and Smart Communities; Climate Change in India – Challenges and Opportunities.

## **REFERENCES**

1. IPCC (Latest Assessment Reports). Climate Change: Synthesis Reports.
2. Dessler, A.E. (2021). Introduction to Modern Climate Change. Cambridge University Press.
3. Maslin, M. (2021). Climate Change: A Very Short Introduction. Oxford University Press.
4. Houghton, J. (2015). Global Warming: The Complete Briefing. Cambridge University Press.
5. Henderson-Sellers, A. and Robinson, P.J. (2013). Contemporary Climatology. Routledge.
6. Miller, G.T. and Spoolman, S. (2018). Living in the Environment. Cengage Learning.
7. Cunningham, W.P. and Cunningham, M.A. (2020). Environmental Science: A Global Concern. McGraw-Hill Education.
8. Sachs, J.D. (2015). The Age of Sustainable Development. Columbia University Press.
9. United Nations (2015). Transforming Our World: The 2030 Agenda for Sustainable Development.
10. UNEP Global Environment Outlook Reports.
11. MoEFCC, Government of India. National Action Plan on Climate Change (NAPCC).
12. TERI Publications on Climate Change and Sustainability.
13. Bharucha, E. (2019). Textbook of Environmental Studies. Universities Press.
14. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.
15. United Nations Framework Convention on Climate Change (UNFCCC) Reports.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                        |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Explain the scientific basis of climate change, greenhouse effect, greenhouse gases, natural and anthropogenic causes, and global climate variability.                |
| <b>CO2</b>  | Describe evidence of climate change and explain the functioning of the climate system and the role of climate modeling in understanding future projections.           |
| <b>CO3</b>  | Analyze the impacts of climate change on atmosphere, hydrosphere, lithosphere, biosphere, biodiversity, agriculture, water resources, and human health.               |
| <b>CO4</b>  | Evaluate the risks posed by extreme weather events—floods, droughts, heat waves, cyclones, sea-level rise—and assess community vulnerability.                         |
| <b>CO5</b>  | Understand climate change mitigation strategies including renewable energy technologies, energy efficiency, carbon sequestration, and nature-based solutions.         |
| <b>CO6</b>  | Apply adaptation concepts—climate-resilient agriculture, water adaptation, ecosystem-based adaptation, climate-smart development—to sustainable development planning. |
| <b>CO7</b>  | Explain the principles and dimensions of sustainability—environmental, social, and economic—and evaluate the Sustainable Development Goals (SDGs).                    |
| <b>CO8</b>  | Assess the concepts of circular economy, ecological footprint, carbon footprint, ESG principles, and sustainable consumption and production.                          |
| <b>CO9</b>  | Evaluate international climate agreements—Paris Agreement, COP summits, carbon markets, climate finance—and understand the role of climate justice and equity.        |
| <b>CO10</b> | Develop informed perspectives on climate action, low-carbon development, sustainable cities, and solutions addressing climate challenges in the Indian context.       |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 2   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO4       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 2    |
| CO5       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 3    |
| CO6       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 3    |
| CO7       | 1   | 3   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 3    |
| CO8       | 1   | 3   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |
| CO9       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO10      | 3   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

Code:

**ENVIRONMENTAL SAFETY AND  
HEALTH MANAGEMENT  
(Theory)**

Credits: 4

**COURSE OBJECTIVES**

- To introduce the principles and practices of environmental safety and occupational health management.
- To understand workplace hazards, risk assessment, and accident prevention strategies.
- To familiarize students with environmental health issues and safety regulations.
- To develop knowledge on emergency preparedness, disaster management, and occupational safety.
- To promote safe working environments and sustainable health management practices.

**UNIT – I: INTRODUCTION TO ENVIRONMENTAL SAFETY AND HEALTH**

Concept and scope of Environmental Safety and Health Management; Environment, Health, and Safety (EHS) principles; Occupational health and safety; Importance of workplace safety; Types of hazards – physical, chemical, biological, ergonomic, and psychosocial hazards; Environmental health and public health concepts.

**UNIT – II: OCCUPATIONAL HAZARDS AND RISK ASSESSMENT**

Occupational hazards in industries, laboratories, and field environments; Hazard identification and classification; Exposure pathways and health effects; Risk assessment process – hazard identification, exposure assessment, risk characterization, and risk management; Safety signs and symbols; Personal Protective Equipment (PPE) and its applications.

**UNIT – III: INDUSTRIAL SAFETY AND ACCIDENT PREVENTION**

Industrial accidents and their causes; Accident investigation and reporting; Safety audits and inspections; Fire hazards, fire prevention, and fire-fighting equipment; Electrical safety; Chemical safety and hazardous material handling; Safe laboratory practices; Occupational safety measures in environmental monitoring and field studies.

**UNIT – IV: ENVIRONMENTAL HEALTH MANAGEMENT**

Environmental determinants of health; Water, air, and food-related health issues; Vector-borne and waterborne diseases; Waste management and sanitation; Environmental hygiene; Health surveillance and occupational health programmes;

Environmental health indicators and monitoring.

## **UNIT – V: EMERGENCY PREPAREDNESS AND DISASTER MANAGEMENT**

Emergency planning and preparedness; Disaster management cycle – prevention, mitigation, preparedness, response, and recovery; Industrial disasters and environmental emergencies; Chemical spills and hazardous waste incidents; Community-based disaster management; First aid and basic life support measures; Climate-related disasters and adaptation strategies.

## **UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Environmental, Health and Safety (EHS) Management Systems; ISO 14001 and ISO 45001 Standards; Workplace Mental Health and Well-being; Chemical Safety and REACH Regulations; Occupational Health in the Green Economy; Industrial Disaster Case Studies; Climate Change and Public Health; Sustainable Safety Management Practices.

## **REFERENCES**

1. Goetsch, D.L. (2021). Occupational Safety and Health for Technologists, Engineers and Managers. Pearson Education.
2. Friend, M.A. and Kohn, J.P. (2018). Fundamentals of Occupational Safety and Health. Rowman & Littlefield Publishers.
3. Hughes, P. and Ferrett, E. (2020). Introduction to Health and Safety at Work. Routledge.
4. Salvato, J.A., Nemerow, N.L. and Agardy, F.J. (2003). Environmental Engineering and Sanitation. Wiley Publications.
5. Roughton, J. and Crutchfield, N. (2016). Safety Culture: An Innovative Leadership Approach. Butterworth-Heinemann.
6. Frank P. Lees (2012). Lees' Loss Prevention in the Process Industries. Butterworth-Heinemann.
7. Rao, C.S. (2018). Environmental Pollution Control Engineering. New Age International Publishers.
8. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. (2017). Environmental Engineering. McGraw-Hill Education.
9. World Health Organization (WHO). Environmental Health Guidelines and Reports.
10. International Labour Organization (ILO). Occupational Safety and Health Conventions and Guidelines.
11. Ministry of Labour and Employment, Government of India. Occupational Safety and Health Guidelines.
12. National Disaster Management Authority (NDMA), Government of India Publications.
13. Central Pollution Control Board (CPCB) Safety and Environmental Management Manuals.
14. Environmental Protection Agency (EPA) Occupational and Environmental Health Resources.

15. Sharma, P.D. (2020). Ecology and Environment. Rastogi Publications.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO1           | Explain the principles, scope, and significance of Environmental Safety and Health Management, including EHS concepts and occupational health frameworks.             |
| <b>CO2</b>    | Identify and classify workplace hazards—physical, chemical, biological, ergonomic, and psychosocial—and describe their routes of exposure and health effects.         |
| <b>CO3</b>    | Conduct hazard identification and risk assessment following standard procedures including risk characterization, control hierarchies, and safety sign interpretation. |
| <b>CO4</b>    | Apply appropriate Personal Protective Equipment (PPE) and chemical safety practices in laboratory, industrial, and field environments.                                |
| <b>CO5</b>    | Analyze causes of industrial accidents, conduct accident investigation and reporting, and implement safety audit and inspection practices.                            |
| <b>CO6</b>    | Describe fire hazard prevention, electrical safety, chemical safety, and safe laboratory practices essential for occupational safety.                                 |
| <b>CO7</b>    | Understand environmental health determinants—water, air, food—and evaluate vector-borne and waterborne disease management and sanitation practices.                   |
| <b>CO8</b>    | Develop and evaluate environmental health surveillance, occupational health programmes, and environmental health monitoring strategies for communities.               |
| <b>CO9</b>    | Prepare emergency preparedness and disaster management plans for industrial, chemical, and climate-related disasters following the disaster management cycle.         |
| <b>CO10</b>   | Evaluate EHS management systems—ISO 14001, ISO 45001—and promote sustainable safety and health practices in professional and community settings.                      |

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 2    |
| CO4       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO5       | 2   | 3   | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 2    |
| CO6       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO9       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO10      | 2   | 3   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

**Code:****VERMICOMPOSTING  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To understand the principles and importance of organic waste management through vermicomposting.
- To gain knowledge about earthworm biology and vermicomposting techniques.
- To develop skills in the production and utilization of vermicompost.
- To promote entrepreneurship opportunities in organic farming and waste management.

**UNIT – I**

Introduction to Organic Waste Management: Types and sources of biodegradable wastes; Environmental impacts of improper waste disposal; Concept, importance, and advantages of vermicomposting; Scope of vermicomposting in sustainable agriculture.

**UNIT – II**

Earthworms and Their Role: Classification and biology of earthworms; Ecological categories of earthworms; Common vermicomposting species (*Eisenia fetida*, *Eudrilus eugeniae*, *Perionyx excavatus*); Role of earthworms in soil fertility and nutrient cycling.

**UNIT – III**

Vermicomposting Techniques: Site selection; Vermibeds and vermibins; Raw materials for vermicomposting; Preparation of feedstock; Methods of vermicomposting; Factors affecting vermicomposting – temperature, moisture, pH, aeration, and substrate quality.

**UNIT – IV**

Production and Quality Assessment: Harvesting and processing of vermicompost; Characteristics of good-quality vermicompost; Nutrient content (NPK); Vermiwash production and applications; Quality control and storage.

**UNIT – V**

Applications and Entrepreneurship: Use of vermicompost in agriculture, horticulture, and landscaping; Economic aspects of vermicomposting; Small-scale enterprise development; Marketing of vermicompost and vermiwash; Government schemes and support for organic farming.

## **UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Organic Farming in India; Natural Farming; Circular Economy and Waste-to-Wealth Initiatives; Urban Composting; Swachh Bharat Mission; Sustainable Agriculture and Soil Health.

### **REFERENCES**

1. Edwards, C.A. and Arancon, N.Q. Vermiculture Technology: Earthworms, Organic Wastes and Environmental Management. CRC Press.
2. Ismail, S.A. Vermicology: The Biology of Earthworms. Orient Longman.
3. Kale, R.D. Earthworms: Nature's Gift for Sustainable Agriculture. Prism Books.
4. Satchel, J.E. Earthworm Ecology. Springer.
5. ICAR Manuals on Organic Farming and Vermicomposting.
6. Ministry of Agriculture and Farmers Welfare Publications.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                                                               |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Understand the principles, importance, and environmental benefits of organic waste management through vermicomposting and its scope in sustainable agriculture.                                     |
| <b>CO2</b>    | Identify and classify common vermicomposting earthworm species— <i>Eisenia fetida</i> , <i>Eudrilus eugeniae</i> , <i>Perionyx excavatus</i> —and explain their biological role in soil enrichment. |
| <b>CO3</b>    | Describe the ecological categories of earthworms and explain their contribution to nutrient cycling, soil fertility, and ecosystem productivity.                                                    |
| <b>CO4</b>    | Explain the methods, site selection criteria, and construction of vermibeds and vermibins for efficient vermicomposting operations.                                                                 |
| <b>CO5</b>    | Analyze the key factors influencing vermicompost quality—temperature, moisture, pH, aeration, and substrate composition—and implement control measures.                                             |
| <b>CO6</b>    | Describe the harvesting, processing, and quality assessment of vermicompost including nutrient content analysis (NPK) and storage methods.                                                          |
| <b>CO7</b>    | Explain the production and agricultural applications of vermiwash and evaluate its role as a liquid bio-fertilizer in crop management.                                                              |
| <b>CO8</b>    | Evaluate the use of vermicompost and vermiwash in agriculture, horticulture, and landscaping and assess their economic advantages over chemical fertilizers.                                        |
| <b>CO9</b>    | Develop entrepreneurial skills in small-scale                                                                                                                                                       |

|             |                                                                                                                                                       |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | vermicomposting enterprise development including marketing, branding, and application for government schemes.                                         |
| <b>CO10</b> | Promote waste-to-resource and circular economy approaches through vermicomposting for sustainable environmental management and community development. |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO4       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO5       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO6       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO7       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO10      | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

**Code:****AQUAPONICS  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To introduce the concept and principles of aquaponics as a sustainable food production system.
- To understand the integration of aquaculture and hydroponics.
- To develop knowledge on aquaponic system design, operation, and maintenance.
- To promote sustainable agriculture, water conservation, and entrepreneurship.

**UNIT – I**

Introduction to Aquaponics: Concept, history, and principles of aquaponics; Components of aquaponic systems; Advantages and limitations; Aquaponics and sustainable food production; Comparison with conventional agriculture.

**UNIT – II**

Aquaculture Components: Common fish species used in aquaponics; Fish biology and culture requirements; Water quality parameters; Fish nutrition and feeding practices; Fish health management.

**UNIT – III**

Hydroponic Components: Principles of hydroponics; Plant growth requirements; Nutrient cycling in aquaponics; Suitable crops for aquaponic cultivation; Plant health and pest management.

**UNIT – IV**

Aquaponic System Design and Operation: Types of aquaponic systems – Media Bed, Nutrient Film Technique (NFT), Deep Water Culture (DWC); System components and construction; Water circulation and filtration; Monitoring and maintenance.

**UNIT – V**

Applications and Entrepreneurship: Commercial and household aquaponics; Economic feasibility; Resource efficiency and water conservation; Marketing opportunities; Urban farming and startup potential; Government initiatives supporting sustainable agriculture.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Smart Farming Technologies; Urban Agriculture; Vertical Farming; Climate-Resilient Food Systems; Water-Efficient

Agriculture; Sustainable Development Goals and Food Security; Aquaponics Start-ups in India.

## REFERENCES

1. Rakocy, J.E., Masser, M.P. and Losordo, T.M. Recirculating Aquaculture Tank Production Systems: Aquaponics.
2. Lennard, W. Aquaponic System Design Parameters. Aquaponic Solutions.
3. Somerville, C., Cohen, M., Pantanella, E., Stankus, A. and Lovatelli, A. Small-Scale Aquaponic Food Production. FAO Fisheries and Aquaculture Technical Paper.
4. Diver, S. Aquaponics – Integration of Hydroponics with Aquaculture. ATTRA Publications.
5. FAO Aquaponics Training Manuals.
6. ICAR Publications on Integrated Farming Systems.

## COURSE OUTCOMES

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

| CO No. | Course Outcome                                                                                                                                                           |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO1    | Explain the concept, historical background, and principles of aquaponics as an integrated sustainable food production system.                                            |
| CO2    | Describe the components of aquaponic systems and compare aquaponics with conventional aquaculture and hydroponics in terms of resource efficiency.                       |
| CO3    | Identify common fish species suitable for aquaponics, understand their culture requirements, water quality needs, and feeding and health management practices.           |
| CO4    | Explain the principles of hydroponics, nutrient cycling in aquaponic systems, and identify suitable crops for integrated aquaponic cultivation.                          |
| CO5    | Describe the design, construction, and operation of different aquaponic system types—Media Bed, NFT, and DWC—and explain water circulation and filtration.               |
| CO6    | Monitor basic water quality parameters and system performance indicators essential for maintaining healthy aquaponic production systems.                                 |
| CO7    | Evaluate the environmental benefits of aquaponics in terms of water conservation, sustainable food production, and reduction of agricultural chemical use.               |
| CO8    | Assess the economic feasibility, resource efficiency, and commercial potential of aquaponic systems for household and institutional applications.                        |
| CO9    | Develop entrepreneurial knowledge in urban farming, aquaponics business planning, marketing, and awareness of government initiatives supporting sustainable agriculture. |
| CO10   | Promote aquaponics as a sustainable food system aligned with SDGs, climate-resilient agriculture, and circular economy principles.                                       |

## CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO6       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 1   | 2    |
| CO7       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO8       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO10      | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

**Code:****RAINWATER HARVESTING  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To understand the importance of rainwater harvesting for water conservation and sustainable water management.
- To gain knowledge about various rainwater harvesting techniques and structures.
- To develop skills in planning, designing, and maintaining rainwater harvesting systems.
- To create awareness about groundwater recharge and water security.

**UNIT – I**

Introduction to Water Resources: Global and national water resources; Water scarcity and water stress; Importance of water conservation; Need for rainwater harvesting; Traditional water harvesting systems in India.

**UNIT – II**

Principles of Rainwater Harvesting: Hydrological cycle and precipitation; Surface runoff and infiltration; Concepts and objectives of rainwater harvesting; Benefits and limitations of rainwater harvesting.

**UNIT – III**

Rainwater Harvesting Techniques: Rooftop rainwater harvesting; Surface runoff harvesting; Recharge pits, recharge trenches, recharge wells, percolation ponds, farm ponds, and check dams; Urban and rural rainwater harvesting systems.

**UNIT – IV**

Design and Installation of Rainwater Harvesting Systems: Components of rainwater harvesting systems; Catchment area, conveyance system, filtration unit, storage structures; Estimation of water harvesting potential; Maintenance and monitoring.

**UNIT – V**

Applications and Sustainable Water Management: Groundwater recharge; Community-based water conservation; Rainwater harvesting in institutions and residential buildings; Government policies and schemes; Case studies of successful rainwater harvesting projects.

## **UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Jal Shakti Abhiyan; Atal Bhujal Yojana; Urban Water Security; Climate Change and Water Conservation; Smart Water Management; Nature-Based Solutions for Water Sustainability.

### **REFERENCES**

1. Agarwal, A. and Narain, S. Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems. Centre for Science and Environment.
2. Gould, J. and Nissen-Petersen, E. Rainwater Catchment Systems for Domestic Supply. Intermediate Technology Publications.
3. Thomas, T. Rainwater Harvesting for Human Survival. International Book Distributors.
4. Ministry of Jal Shakti, Government of India Publications.
5. Centre for Science and Environment (CSE) Manuals on Rainwater Harvesting.
6. UNEP Water Conservation Reports.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                                  |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Understand the importance of rainwater harvesting in addressing water scarcity and contributing to sustainable water resource management at local and national levels. |
| <b>CO2</b>    | Explain traditional water harvesting systems of India and describe their ecological, cultural, and hydrological significance.                                          |
| <b>CO3</b>    | Describe the hydrological cycle, precipitation patterns, surface runoff, and infiltration processes that govern rainwater availability and harvesting potential.       |
| <b>CO4</b>    | Identify and explain various rainwater harvesting techniques—rooftop harvesting, percolation ponds, recharge pits, check dams, and farm ponds.                         |
| <b>CO5</b>    | Differentiate between urban and rural rainwater harvesting systems and explain their respective design requirements and applications.                                  |
| <b>CO6</b>    | Estimate rainwater harvesting potential for specific locations based on catchment area, rainfall data, and system efficiency parameters.                               |
| <b>CO7</b>    | Describe the components—catchment area, conveyance system, filtration unit, and storage structures—and explain principles of installation and maintenance.             |
| <b>CO8</b>    | Evaluate the role of rainwater harvesting in groundwater recharge and long-term water security for communities and institutions.                                       |

|             |                                                                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO9</b>  | Analyze national schemes and government policies—Jal Shakti Abhiyan, Atal Bhujal Yojana—supporting rainwater harvesting and sustainable water management. |
| <b>CO10</b> | Promote community-based water conservation practices and develop awareness of smart water management solutions for climate-resilient water security.      |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 1    |
| CO5       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 1    |
| CO6       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO8       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 2    |
| CO10      | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

**Code:****CARBON BUDGETING  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To introduce the concept of carbon budgeting and carbon accounting.
- To understand carbon sources, sinks, and the global carbon cycle.
- To develop skills for estimating carbon footprints and greenhouse gas emissions.
- To create awareness about climate change mitigation and carbon management strategies.

**UNIT – I**

Introduction to Carbon and Climate Change: Carbon cycle and carbon reservoirs; Greenhouse gases and global warming; Climate change and its impacts; Concept of carbon neutrality and net-zero emissions.

**UNIT – II**

Carbon Sources and Carbon Sinks: Natural and anthropogenic sources of carbon emissions; Fossil fuel combustion; Land use and land cover changes; Forests, wetlands, and oceans as carbon sinks; Carbon sequestration.

**UNIT – III**

Principles of Carbon Budgeting: Carbon footprint and carbon accounting; Components of carbon budgeting; Carbon inventory; Measurement units and emission factors; Scope 1, Scope 2, and Scope 3 emissions.

**UNIT – IV**

Carbon Estimation and Assessment: Estimation of carbon emissions from transportation, energy consumption, and waste generation; Calculation of personal, household, and institutional carbon footprints; Introduction to carbon calculators and assessment tools.

**UNIT – V**

Carbon Management and Mitigation: Carbon offsetting; Carbon credits and carbon trading; Renewable energy and energy efficiency; Nature-based solutions; Sustainable lifestyles and low-carbon development strategies.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

India's Net Zero Commitment; Carbon Markets; Green Buildings; Carbon-Neutral Campuses; Blue Carbon Ecosystems; Corporate

## Carbon Disclosure; Climate Action and Sustainable Development Goals.

### REFERENCES

1. IPCC Assessment Reports on Climate Change.
2. Berners-Lee, M. How Bad Are Bananas? The Carbon Footprint of Everything. Profile Books.
3. Wiedmann, T. and Minx, J. A Definition of Carbon Footprint. Ecological Economics Research Trends.
4. UNEP Emissions Gap Reports.
5. Ministry of Environment, Forest and Climate Change (MoEFCC) Publications.
6. World Resources Institute (WRI) Greenhouse Gas Protocol Guides.
7. Intergovernmental Panel on Climate Change (IPCC) Carbon Accounting Guidelines.

### COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                      |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the fundamentals of carbon budgeting and carbon accounting and explain their role in climate change monitoring and management.                           |
| <b>CO2</b>  | Explain the global carbon cycle, carbon reservoirs, greenhouse gases, and their contribution to global warming and climate change.                                  |
| <b>CO3</b>  | Identify natural and anthropogenic sources of carbon emissions—fossil fuel combustion, land use change—and recognize forests, wetlands, and oceans as carbon sinks. |
| <b>CO4</b>  | Explain the principles of carbon footprint calculation, carbon inventory development, and the distinction between Scope 1, 2, and 3 emissions.                      |
| <b>CO5</b>  | Estimate carbon emissions from transportation, energy consumption, and waste generation at personal, household, and institutional levels.                           |
| <b>CO6</b>  | Apply carbon calculators and assessment tools to measure and compare carbon footprints across different activities and sectors.                                     |
| <b>CO7</b>  | Evaluate carbon management strategies—offsetting, carbon credits, carbon trading, renewable energy adoption, and nature-based solutions.                            |
| <b>CO8</b>  | Assess India's net zero commitments, carbon market developments, corporate carbon disclosure, and green building practices.                                         |
| <b>CO9</b>  | Promote low-carbon lifestyles including sustainable consumption, energy conservation, and climate-conscious decision-making in daily life.                          |
| <b>CO10</b> | Develop awareness of circular carbon economy concepts—blue carbon ecosystems, bioenergy,                                                                            |

|  |                                                                      |
|--|----------------------------------------------------------------------|
|  | sustainable agriculture—and their role in global climate mitigation. |
|--|----------------------------------------------------------------------|

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO6       | 1   | 2   | 3   | 3   | 3   | 3   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO9       | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |
| CO10      | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |

**Code:****CIRCULAR ECONOMY  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To introduce the principles and concepts of the circular economy.
- To understand resource efficiency, waste minimization, and sustainable production systems.
- To develop knowledge on circular business models and resource recovery strategies.
- To promote sustainable consumption and environmental stewardship.

**UNIT – I**

Introduction to Circular Economy: Definition, principles, and evolution of circular economy; Linear economy versus circular economy; Resource scarcity and sustainable development; Circular economy and Sustainable Development Goals (SDGs).

**UNIT – II**

Resource Efficiency and Waste Minimization: Concepts of Reduce, Reuse, Recycle, Recover, and Refurbish (5Rs); Material flow analysis; Resource conservation; Industrial ecology; Life cycle thinking.

**UNIT – III**

Circular Business Models: Product life extension; Sharing economy; Product-as-a-service model; Green entrepreneurship; Sustainable supply chains; Eco-industrial parks and industrial symbiosis.

**UNIT – IV**

Waste-to-Resource Technologies: Composting, vermicomposting, bimethanation, recycling technologies; Material Recovery Facilities (MRFs); Urban mining and biomining; Resource recovery from municipal solid waste, e-waste, and construction waste.

**UNIT – V**

Applications and Policy Framework: Circular economy practices in agriculture, manufacturing, and urban systems; Circular economy policies in India; Extended Producer Responsibility (EPR); Case studies of successful circular economy initiatives.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Plastic Waste Management Rules; Circular Economy Action Plans; Green Manufacturing; Zero Waste Cities; Resource-Efficient and

Cleaner Production (RECP); ESG and Circular Economy; Circular Economy in India.

## REFERENCES

1. Ellen MacArthur Foundation. Towards the Circular Economy.
2. Stahel, W.R. The Circular Economy: A User's Guide. Routledge.
3. Lacy, P. and Rutqvist, J. Waste to Wealth: The Circular Economy Advantage. Palgrave Macmillan.
4. Kirchherr, J., Reike, D. and Hekkert, M. Conceptualizing the Circular Economy. Resources, Conservation and Recycling.
5. Ministry of Environment, Forest and Climate Change (MoEFCC) Publications.
6. Centre for Science and Environment (CSE) Reports on Waste Management.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                 |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the definition, principles, evolution, and significance of the circular economy and differentiate it from the conventional linear economy model.    |
| <b>CO2</b>  | Explain the relationship between circular economy, resource scarcity, and sustainable development goals at national and global levels.                         |
| <b>CO3</b>  | Apply the concepts of Reduce, Reuse, Recycle, Recover, and Refurbish (5Rs) to analyze material flows and resource conservation strategies.                     |
| <b>CO4</b>  | Describe material flow analysis, industrial ecology, life cycle thinking, and their role in designing resource-efficient systems.                              |
| <b>CO5</b>  | Identify and evaluate circular business models—product life extension, sharing economy, product-as-a-service, eco-industrial parks—for sustainable production. |
| <b>CO6</b>  | Analyze waste-to-resource technologies including composting, biomethanation, recycling, Material Recovery Facilities (MRF), and urban mining.                  |
| <b>CO7</b>  | Evaluate resource recovery approaches for municipal solid waste, e-waste, and construction waste within the circular economy framework.                        |
| <b>CO8</b>  | Analyze circular economy practices in agriculture, manufacturing, and urban systems and examine relevant Indian and global policy frameworks.                  |
| <b>CO9</b>  | Assess Extended Producer Responsibility (EPR) regulations and examine case studies of successful circular economy initiatives from India and abroad.           |
| <b>CO10</b> | Promote sustainable consumption, resource conservation, and environmentally responsible practices aligned with circular economy principles.                    |

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO6       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO9       | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO10      | 3   | 3   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

**Code:****ECO-FRIENDLY PRODUCTS  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To introduce eco-friendly products and their role in environmental sustainability.
- To understand the principles of green product design and sustainable production.
- To develop knowledge on environmentally responsible consumer choices.
- To encourage entrepreneurship in the development and marketing of eco-friendly products.

**UNIT – I**

Introduction to Eco-Friendly Products: Concept and importance; Environmental impacts of conventional products; Green consumerism; Sustainable production and consumption; Eco-labeling and environmental certification.

**UNIT – II**

Natural and Biodegradable Products: Biodegradable materials; Natural fibers and products; Bamboo-based products; Areca leaf products; Coir products; Jute products; Organic personal care products and natural dyes.

**UNIT – III**

Eco-Friendly Alternatives to Conventional Products: Alternatives to single-use plastics; Reusable bags, containers, and packaging materials; Compostable products; Sustainable household products; Green office supplies.

**UNIT – IV**

Green Product Development and Manufacturing: Principles of eco-design; Product life cycle assessment; Sustainable packaging; Resource-efficient manufacturing; Quality standards and environmental certification.

**UNIT – V**

Entrepreneurship and Marketing: Small-scale production of eco-friendly products; Business opportunities; Marketing strategies; Branding and eco-labeling; Government schemes supporting green enterprises; Success stories of eco-friendly startups.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Plastic-Free Campaigns; Green Startups in India; Sustainable Fashion; Eco-Friendly Packaging Innovations; Bio-based Products; Circular Product Design; Responsible Consumption

and Production (SDG 12).

## REFERENCES

1. Charter, M. and Tischner, U. Sustainable Solutions: Developing Products and Services for the Future. Greenleaf Publishing.
2. Vezzoli, C. Design for Environmental Sustainability. Springer.
3. Papanek, V. Design for the Real World: Human Ecology and Social Change. Thames & Hudson.
4. Ministry of MSME Publications on Green Enterprises.
5. United Nations Environment Programme (UNEP) Reports on Sustainable Consumption and Production.
6. Government of India Publications on Eco-labeling and Green Products.

## COURSE OUTCOMES

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

| CO No. | Course Outcome                                                                                                                                                 |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO1    | Understand the significance of eco-friendly products in reducing environmental impacts and advancing sustainable production and consumption practices.         |
| CO2    | Identify and classify natural and biodegradable product alternatives—bamboo, areca leaf, coir, jute, organic textiles—and explain their ecological advantages. |
| CO3    | Explain eco-labeling systems, environmental certifications, and green consumerism principles in supporting sustainable market choices.                         |
| CO4    | Describe eco-friendly alternatives to single-use plastics including reusable bags, compostable containers, and sustainable packaging materials.                |
| CO5    | Apply principles of eco-design and life cycle assessment (LCA) to evaluate the environmental footprint of product development and manufacturing.               |
| CO6    | Understand resource-efficient manufacturing, quality standards, and environmental certification processes relevant to green product industries.                |
| CO7    | Evaluate the environmental and economic benefits of eco-friendly products compared to conventional products across multiple sectors.                           |
| CO8    | Analyze current trends in sustainable fashion, bio-based products, circular product design, and plastic-free initiatives in India and globally.                |
| CO9    | Develop entrepreneurial skills for small-scale production, marketing, and branding of eco-friendly products supported by government green enterprise schemes.  |
| CO10   | Promote responsible consumption, eco-conscious lifestyles, and sustainable development aligned with SDG 12 on sustainable production and consumption.          |

## CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO4       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO5       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2    |
| CO6       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO7       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO10      | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

**Code:****INTELLECTUAL PROPERTY RIGHTS  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To introduce the concepts and significance of Intellectual Property Rights (IPR).
- To understand different forms of intellectual property protection and their applications.
- To develop awareness of innovation, creativity, and legal protection of intellectual assets.
- To familiarize students with IPR issues related to biodiversity, traditional knowledge, and environmental technologies.

**UNIT – I**

Introduction to Intellectual Property Rights: Definition, concept, and importance of IPR; Evolution of IPR; Role of IPR in innovation, research, and economic development; Intellectual property and knowledge economy.

**UNIT – II**

Types of Intellectual Property Rights: Patents, Copyrights, Trademarks, Industrial Designs, Geographical Indications (GI), Trade Secrets, and Plant Variety Protection; Features, scope, and duration of protection.

**UNIT – III**

Patent System and Innovation: Patentable and non-patentable inventions; Patent application process; Patent search and documentation; Technology transfer and commercialization; Case studies on patents and innovations.

**UNIT – IV**

IPR and Biodiversity: Biodiversity and intellectual property; Traditional knowledge and biopiracy; Access and Benefit Sharing (ABS); Protection of indigenous knowledge systems; Biological Diversity Act and related provisions.

**UNIT – V**

IPR Management and Entrepreneurship: Intellectual property management; Licensing and technology transfer; Start-ups and innovation ecosystems; IPR in environmental technologies and green innovations; Role of IPR in sustainable development.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Traditional Knowledge Digital Library (TKDL); Geographical

Indications in India; Green Patents; Open Innovation; Artificial Intelligence and IPR; Biodiversity Conservation and Benefit Sharing; Intellectual Property in the Bioeconomy.

## REFERENCES

1. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy. Tata McGraw-Hill.
2. Narayanan, P. Intellectual Property Law. Eastern Law House.
3. Cornish, W. and Llewelyn, D. Intellectual Property: Patents, Copyrights, Trademarks and Allied Rights. Sweet & Maxwell.
4. WIPO Publications on Intellectual Property Rights.
5. World Trade Organization (WTO) – TRIPS Agreement Documents.
6. National Intellectual Property Rights Policy, Government of India.
7. Biological Diversity Act, 2002 and National Biodiversity Authority Publications.

## COURSE OUTCOMES

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

| CO No.     | Course Outcome                                                                                                                                                            |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b> | Understand the definition, concept, and significance of Intellectual Property Rights (IPR) and their role in fostering innovation, research, and economic development.    |
| <b>CO2</b> | Distinguish the major types of intellectual property—patents, copyrights, trademarks, GI, industrial designs, trade secrets, plant variety protection—and their features. |
| <b>CO3</b> | Explain the criteria for patentability, the patent application process, patent search and documentation, and the relationship between patents and technology transfer.    |
| <b>CO4</b> | Analyze case studies of innovations and patents relevant to environmental science, green technologies, and sustainable development.                                       |
| <b>CO5</b> | Describe the relationship between IPR and biodiversity, including traditional knowledge, biopiracy, Access and Benefit Sharing (ABS), and related legislation.            |
| <b>CO6</b> | Explain the Biological Diversity Act provisions relevant to IPR, indigenous knowledge systems, and protection of biodiversity-related intellectual assets.                |
| <b>CO7</b> | Apply IPR concepts in the context of green innovations, environmental technologies, and sustainable development entrepreneurship.                                         |
| <b>CO8</b> | Analyze the Traditional Knowledge Digital Library (TKDL), Geographical Indications of India, and their role in protecting indigenous environmental knowledge.             |
| <b>CO9</b> | Develop skills in intellectual property management                                                                                                                        |

|             |                                                                                                                           |
|-------------|---------------------------------------------------------------------------------------------------------------------------|
|             | including licensing, technology transfer, and building start-ups within innovation ecosystems.                            |
| <b>CO10</b> | Appreciate the role of IPR in sustainable development, circular economy, knowledge management, and the global bioeconomy. |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO4       | 1   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO6       | 2   | 3   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |
| CO7       | 1   | 3   | 3   | 2   | 2   | 3   | 2   | 2   | 2   | 3    |
| CO8       | 2   | 3   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO10      | 2   | 3   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 3    |

**Code: ENVIRONMENTAL QUALITY ASSESSMENT  
(Theory)**

**Credits: 2**

**COURSE OBJECTIVES**

- To introduce the principles of environmental quality assessment and monitoring.
- To understand the indicators and standards used for assessing environmental quality.
- To develop skills in environmental data collection, interpretation, and reporting.
- To familiarize students with environmental monitoring techniques used in air, water, soil, and noise quality assessment.

**UNIT – I**

Introduction to Environmental Quality Assessment: Concept and significance; Environmental quality indicators; Environmental standards and guidelines; Environmental monitoring and assessment framework.

**UNIT – II**

Air Quality Assessment: Sources of air pollution; Ambient air quality monitoring; Air Quality Index (AQI); Particulate matter and gaseous pollutants; National Ambient Air Quality Standards (NAAQS); Interpretation of air quality data.

**UNIT – III**

Water Quality Assessment: Water quality parameters – physical, chemical, and biological; Water Quality Index (WQI); Drinking water standards; Surface water and groundwater quality assessment; Water sampling and monitoring techniques.

**UNIT – IV**

Soil and Noise Quality Assessment: Soil quality indicators; Soil contamination and assessment methods; Noise pollution and measurement; Noise quality standards; Environmental implications of degraded soil and noise pollution.

**UNIT – V**

Environmental Monitoring Tools and Reporting: Environmental sampling techniques; Field and laboratory monitoring methods; Data recording and interpretation; Environmental audit and reporting; Use of GIS and digital tools in environmental assessment.

## **UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Smart Environmental Monitoring Systems; Low-Cost Sensors for Environmental Assessment; Citizen Science and Environmental Monitoring; Real-Time Air Quality Monitoring; Environmental Data Analytics; ESG Reporting and Sustainability Indicators.

### **REFERENCES**

1. Rao, C.S. Environmental Pollution Control Engineering. New Age International Publishers.
2. APHA. Standard Methods for the Examination of Water and Wastewater.
3. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. Environmental Engineering. McGraw-Hill.
4. Trivedi, R.K. and Goel, P.K. Environmental Pollution Studies. Environmental Publications.
5. Central Pollution Control Board (CPCB) Manuals and Guidelines.
6. UNEP Environmental Monitoring and Assessment Reports.
7. World Health Organization (WHO) Environmental Quality Guidelines.

### **COURSE OUTCOMES**

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

| <b>CO No.</b> | <b>Course Outcome</b>                                                                                                                                                                  |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>    | Understand the concepts, significance, and framework of environmental quality assessment and identify major environmental quality indicators.                                          |
| <b>CO2</b>    | Explain national and international environmental standards and guidelines for air, water, soil, and noise quality monitoring.                                                          |
| <b>CO3</b>    | Describe sources, types, and effects of air pollution and explain the Air Quality Index (AQI), National Ambient Air Quality Standards (NAAQS), and interpretation of air quality data. |
| <b>CO4</b>    | Explain water quality parameters—physical, chemical, and biological—and apply the Water Quality Index (WQI) to assess drinking and surface water quality.                              |
| <b>CO5</b>    | Describe soil quality indicators and soil contamination assessment methods and evaluate the environmental significance of soil degradation.                                            |
| <b>CO6</b>    | Understand noise pollution measurement, noise quality standards, and assessment of environmental noise impacts on human health and wildlife.                                           |
| <b>CO7</b>    | Apply environmental sampling techniques and field and laboratory monitoring methods for systematic environmental quality data collection.                                              |
| <b>CO8</b>    | Interpret environmental monitoring data, quality indices, and reporting formats used for environmental                                                                                 |

|             |                                                                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | audit and compliance assessment.                                                                                                                            |
| <b>CO9</b>  | Use GIS, digital tools, and smart sensor technologies for advanced environmental monitoring, data analytics, and quality assessment reporting.              |
| <b>CO10</b> | Apply environmental quality assessment findings to support evidence-based environmental management, regulatory compliance, and sustainable decision-making. |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 3   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO4       | 1   | 3   | 2   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO5       | 1   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO6       | 1   | 2   | 2   | 2   | 3   | 2   | 2   | 2   | 1   | 1    |
| CO7       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO8       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO9       | 1   | 2   | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2    |
| CO10      | 2   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 2   | 3    |

**COURSE OBJECTIVES**

- To introduce the concepts and principles of environmental education and sustainability.
- To develop environmental awareness and responsible citizenship.
- To understand environmental issues and their relationship with sustainable development.
- To promote sustainable lifestyles and environmental stewardship.

**UNIT – I**

Introduction to Environment and Sustainability: Concept of environment; Components of environment; Environmental issues and challenges; Sustainable development and its goals; Role of environmental education in sustainability.

**UNIT – II**

Natural Resources and Conservation: Forest, water, land, mineral, and energy resources; Resource depletion; Conservation and sustainable utilization of natural resources.

**UNIT – III**

Environmental Problems and Solutions: Pollution, climate change, biodiversity loss, deforestation, and waste generation; Sustainable solutions and mitigation measures.

**UNIT – IV**

Environmental Ethics and Sustainable Lifestyles: Environmental ethics; Responsible consumption; Green practices; Sustainable communities; Role of individuals in environmental protection.

**UNIT – V**

Environmental Education and Public Participation: Environmental awareness programmes; Community participation; Environmental movements; Environmental communication and advocacy.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Sustainable Development Goals (SDGs); Mission LiFE (Lifestyle for Environment); Climate Action; Green Campuses; Youth Participation in Sustainability.

## REFERENCES

1. Bharucha, E. Textbook of Environmental Studies. Universities Press.
2. Palmer, J. Environmental Education in the 21st Century. Routledge.
3. UNESCO. Education for Sustainable Development Resources.
4. Cunningham, W.P. and Cunningham, M.A. Environmental Science: A Global Concern.
5. UNEP Environmental Education Reports.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                     |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the concept of environment, its components, and the principles and significance of environmental education for sustainable development.                 |
| <b>CO2</b>  | Explain major environmental challenges—pollution, climate change, biodiversity loss, deforestation, and waste—and their relationship with sustainable development. |
| <b>CO3</b>  | Identify and describe sustainable natural resource management practices for forests, water, land, minerals, and energy resources.                                  |
| <b>CO4</b>  | Apply principles of environmental ethics and responsible consumption to adopt green practices and sustainable lifestyles in daily life.                            |
| <b>CO5</b>  | Understand the significance of environmental education programmes, community participation, and environmental movements in promoting public awareness.             |
| <b>CO6</b>  | Explain the Sustainable Development Goals (SDGs) and relate them to environmental education, climate action, and sustainable living.                               |
| <b>CO7</b>  | Develop communication skills for environmental advocacy, community engagement, and promoting environmental stewardship at individual and group levels.             |
| <b>CO8</b>  | Participate actively in environmental conservation and awareness activities such as green campus initiatives and youth sustainability programs.                    |
| <b>CO9</b>  | Evaluate the role of Mission LiFE (Lifestyle for Environment) and similar national frameworks in encouraging sustainable lifestyle changes.                        |
| <b>CO10</b> | Develop a sense of environmental responsibility and commitment to sustainable development as informed and engaged citizens.                                        |

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 1   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO4       | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 3    |
| CO5       | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |
| CO6       | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 3    |
| CO7       | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |
| CO8       | 3   | 2   | 2   | 1   | 1   | 3   | 3   | 1   | 1   | 3    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 3    |
| CO10      | 3   | 2   | 2   | 2   | 2   | 3   | 3   | 2   | 1   | 3    |

Code:

**ENVIRONMENT AND HEALTH  
(Theory)****Credits: 2****COURSE OBJECTIVES**

- To understand the relationship between environment and human health.
- To study environmental factors affecting public health.
- To create awareness about environmental diseases and preventive measures.
- To promote healthy and sustainable living practices.

**UNIT – I**

Introduction to Environmental Health: Concept and scope; Environmental determinants of health; Human health and ecosystem health; Public health and environmental quality.

**UNIT – II**

Air, Water, and Food Quality: Air pollution and health effects; Water quality and waterborne diseases; Food contamination and food safety; Environmental sanitation.

**UNIT – III**

Environmental Diseases: Communicable and non-communicable diseases; Vector-borne diseases; Occupational health hazards; Emerging environmental health issues.

**UNIT – IV**

Waste Management and Health: Solid waste, biomedical waste, e-waste, and plastic waste; Health impacts of improper waste disposal; Waste management practices.

**UNIT – V**

Health Promotion and Environmental Protection: Healthy lifestyle practices; Environmental hygiene; Community health programmes; Role of government and public participation.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

One Health Concept; Climate Change and Health; Air Quality and Public Health; Microplastics and Human Health; Environmental Health Surveillance.

**REFERENCES**

1. Friis, R.H. Essentials of Environmental Health.
2. WHO Environmental Health Guidelines.
3. Park, K. Preventive and Social Medicine.
4. Salvato, J.A. Environmental Engineering and Sanitation.

## 5. UNEP and WHO Environmental Health Reports.

### COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                       |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the relationship between environment and human health, including the scope of environmental health and concept of ecosystem health.       |
| <b>CO2</b>  | Identify environmental determinants of health—air, water, food, soil—and explain how environmental quality influences public health outcomes.        |
| <b>CO3</b>  | Describe the effects of air pollution, water contamination, and food safety issues on human health and explain preventive measures.                  |
| <b>CO4</b>  | Analyze communicable and non-communicable diseases caused by environmental factors, including vector-borne diseases and occupational hazards.        |
| <b>CO5</b>  | Evaluate the impacts of solid waste, biomedical waste, e-waste, and plastic waste on human health and explain waste management solutions.            |
| <b>CO6</b>  | Explain waterborne disease transmission, environmental sanitation practices, and the role of safe water supply in public health protection.          |
| <b>CO7</b>  | Assess emerging environmental health issues including microplastics in the human body, climate change-related health risks, and air quality impacts. |
| <b>CO8</b>  | Understand the One Health concept and explain the interconnection between human health, animal health, and ecosystem health.                         |
| <b>CO9</b>  | Promote community awareness regarding environmental hygiene, healthy lifestyle practices, and participation in government health programs.           |
| <b>CO10</b> | Evaluate environmental health risks, develop management strategies, and foster responsibility for sustainable and health-conscious living.           |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO6       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO7       | 2   | 2   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |
| CO8       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO9       | 3   | 2   | 2   | 1   | 1   | 3   | 2   | 1   | 1   | 2    |
| CO10      | 2   | 2   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 3    |

Code:

**GREEN AUDITING  
(Theory)**

Credits: 2

**COURSE OBJECTIVES**

- To introduce the concepts and importance of green auditing.
- To understand environmental performance assessment and sustainability indicators.
- To develop skills in resource auditing and environmental reporting.
- To promote sustainable campus and organizational practices.

**UNIT – I**

Introduction to Green Auditing: Concept, objectives, scope, and significance; Types of environmental audits; Green campus initiatives; Sustainability assessment.

**UNIT – II**

Energy Audit: Energy consumption patterns; Energy efficiency; Renewable energy use; Carbon footprint assessment; Energy conservation measures.

**UNIT – III**

Water Audit: Water use assessment; Water conservation measures; Rainwater harvesting; Wastewater management; Water-use efficiency.

**UNIT – IV**

Waste Audit: Waste generation and characterization; Waste segregation; Recycling and resource recovery; Circular economy concepts; Waste minimization.

**UNIT – V**

Biodiversity and Green Campus Audit: Green cover assessment; Biodiversity documentation; Sustainable transportation; Green procurement; Environmental reporting.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Green Ranking of Institutions; Carbon Neutral Campuses; ESG Reporting; Sustainable Campus Management; Smart Resource Monitoring Systems.

**REFERENCES**

1. UNEP Environmental Audit Guidelines.
2. ISO 14001 Environmental Management Systems Manuals.
3. CPCB Environmental Audit Guidelines.
4. CSE Publications on Green Campuses.

## 5. MoEFCC Environmental Management Resources.

### COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                      |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the concept, objectives, scope, and significance of green auditing as a tool for environmental performance assessment.                   |
| <b>CO2</b>  | Identify and differentiate types of environmental audits and explain their role in promoting sustainability in organizations and institutions.      |
| <b>CO3</b>  | Conduct a basic energy audit by assessing energy consumption patterns, identifying energy-saving opportunities, and calculating carbon footprints.  |
| <b>CO4</b>  | Evaluate renewable energy use, energy efficiency measures, and energy conservation strategies applicable to campus and institutional settings.      |
| <b>CO5</b>  | Perform a water audit by assessing water use patterns, identifying wasteful practices, and recommending conservation and harvesting measures.       |
| <b>CO6</b>  | Conduct a waste audit to characterize waste generation, promote waste segregation, resource recovery, and circular economy principles.              |
| <b>CO7</b>  | Assess biodiversity and green cover in institutional settings through biodiversity documentation and environmental reporting.                       |
| <b>CO8</b>  | Interpret sustainability indicators and audit reports to recommend practical measures for improving the environmental performance of organizations. |
| <b>CO9</b>  | Understand ESG reporting, green ranking systems, and carbon neutrality frameworks applicable to educational institutions and enterprises.           |
| <b>CO10</b> | Promote sustainable campus management, green procurement, and smart resource monitoring systems for environmental excellence.                       |

### CO-PO Mapping

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO3       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO4       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO5       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO6       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO7       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO8       | 2   | 2   | 3   | 3   | 2   | 3   | 3   | 2   | 2   | 2    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |
| CO10      | 3   | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 1   | 3    |

Code:

**MARINE POLLUTION  
(Theory)**

Credits: 2

**COURSE OBJECTIVES**

- To understand the sources, types, and impacts of marine pollution.
- To study the effects of pollutants on marine ecosystems and biodiversity.
- To create awareness about marine conservation and sustainable ocean management.
- To understand national and international efforts for marine pollution control.

**UNIT – I**

Introduction to Marine Environment: Oceans and seas; Marine ecosystems and biodiversity; Importance of marine resources; Coastal and marine environments.

**UNIT – II**

Sources and Types of Marine Pollution: Land-based and sea-based sources; Oil pollution; Plastic pollution; Sewage and industrial discharges; Agricultural runoff; Thermal and radioactive pollution.

**UNIT – III**

Impacts of Marine Pollution: Effects on marine organisms; Coral reef degradation; Eutrophication; Bioaccumulation and biomagnification; Impacts on fisheries and coastal communities.

**UNIT – IV**

Marine Pollution Monitoring and Control: Marine water quality assessment; Pollution monitoring techniques; Waste management in coastal regions; Oil spill management and response.

**UNIT – V**

Marine Conservation and Sustainable Ocean Management: Marine protected areas; Coastal zone management; Blue economy; Ocean governance; Community participation in marine conservation.

**UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only)**

Marine Plastic Debris; Microplastics in Oceans; Blue Carbon Ecosystems; Sustainable Fisheries; UN Decade of Ocean Science; Marine Biodiversity Conservation.

## REFERENCES

1. Clark, R.B. Marine Pollution.
2. Kennish, M.J. Practical Handbook of Marine Science.
3. UNEP Marine Pollution Reports.
4. NOAA Marine Conservation Resources.
5. United Nations Ocean and Climate Reports.

## COURSE OUTCOMES

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

| CO No.      | Course Outcome                                                                                                                                                         |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO1</b>  | Understand the structure and significance of the marine environment including oceans, coastal ecosystems, marine biodiversity, and marine resources.                   |
| <b>CO2</b>  | Identify and explain land-based and sea-based sources of marine pollution including oil spills, plastic debris, sewage, industrial discharge, and agricultural runoff. |
| <b>CO3</b>  | Analyze the effects of marine pollution on marine organisms, coral reefs, and overall marine ecosystem functioning.                                                    |
| <b>CO4</b>  | Describe the processes of eutrophication, bioaccumulation, and biomagnification in marine ecosystems and their cascading impacts on fisheries and food chains.         |
| <b>CO5</b>  | Evaluate monitoring techniques and methodologies used for assessing marine water quality and pollution levels in coastal environments.                                 |
| <b>CO6</b>  | Describe oil spill management strategies, waste management practices in coastal regions, and pollution response mechanisms.                                            |
| <b>CO7</b>  | Understand the concept and significance of Marine Protected Areas (MPAs) and their role in marine biodiversity conservation.                                           |
| <b>CO8</b>  | Analyze blue economy principles, coastal zone management strategies, and ocean governance frameworks for sustainable marine resource use.                              |
| <b>CO9</b>  | Explain the role of community participation, international conventions—UNCLOS, MARPOL—and national policies in marine pollution control.                               |
| <b>CO10</b> | Evaluate emerging marine pollution issues—microplastics in oceans, blue carbon ecosystems, sustainable fisheries—and support ocean conservation.                       |

**CO-PO Mapping**

Mapping Level: 3 = High | 2 = Medium | 1 = Low

| CO/<br>PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CO1       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO2       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO3       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO4       | 1   | 2   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2    |
| CO5       | 1   | 2   | 3   | 3   | 3   | 2   | 2   | 3   | 2   | 2    |
| CO6       | 1   | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO7       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 1   | 2    |
| CO8       | 1   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 1   | 2    |
| CO9       | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 1   | 2    |
| CO10      | 2   | 2   | 3   | 2   | 2   | 3   | 3   | 2   | 2   | 3    |