# DEPARTMENT OF ENVIRONMENTAL BIOTECHNOLOGY

## SCHOOL OF ENVIRONMENTAL SCIENCES

## BHARATHIDASAN UNIVERSITY

## TIRUCHIRAPPALLI - 620 024

**M.Sc., Environmental Science**

**(Program Code: 2PSEVS)**

**Curriculum (CBCS)**

***From Academic year 2025-2026 onwards***

# BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI
## DEPARTMENT OF ENVIRONMENTAL BIOTECHNOLOGY
## M. Sc. Environmental Science Curriculum
***(For the students admitted during the academic year 2025-26 onwards)***

### Program's General Objective

PG Graduates are Professionally Competent with characteristic Knowledge-bank, Skill-set, Mind-set and Pragmatic Wisdom in their chosen fields. PG Graduates demonstrate the desired sense of being seasoned and exhibit unequivocal Spiritedness with excellent qualities of productive contribution to society and nation in the arena Science and Technology. PG Graduates are mentored such that they exert Leadership Latitude in their chosen fields with commitment to novelty and distinction. PG Graduates are directed in understanding of ethical principles and responsibilities, moral and social values in day-to-day life thereby attaining Cultural and Civilized personality. PG Graduates are able to collate information from different kinds of sources and gain a coherent understanding of the subject.

### Program Outcome (PO)

The M.Sc., program provides all essential components to the transformative learning that prepares our graduates to become alumni who make a significant contribution to the society. The courses build students' abilities to think critically, solve problems, generate new ideas and create knowledge and to make connections between academic disciplines.

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|---|---|
| PO1 | This program is designed to develop comprehensive and deep knowledge of the field(s), in which the "one semester" thesis research is embedded. |
| PO2 | The challenging, student-centered curriculum is research - based and technology - Oriented and provides a foundation for life - long learning. |
| PO3 | The program caters to students' interest in different domains of biology – from classical to modern, including varied specializations. |
| PO4 | Training in specialized domain of biology is intended to prepare students to become qualified graduates to address biology-related issues at national and international levels. |

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| PO5 | Biology being evidence-based, the program is grounded with an equal number of laboratory courses in the formal practices of observation, experimentation, testing hypotheses and interpretation. |
| PO6 | Biology relies on applications of quantitative analysis and mathematical reasoning; therefore, the curriculum is designed to train the students to apply descriptive and inferential statistical methods, design and analyse diverse data set and understand the underlying probability in the calculations. |
| PO7 | The program provides training to the students to develop their knowledge and skills to communicate appropriate scientific content, formatting and presentation of data through scientific seminars. |
| PO8 | The program trains the students to understand the relationship between science and society, which enhances their vision to apply their knowledge in health systems, economic growth and sustainable environment. |
| PO9 | The 8-credit research-oriented course engages in rigorous and original research that advances knowledge in their chosen field of study within the discipline. |
| PO10 | Upon successful completion of the M.Sc. Environmental Science program with grade 9.0 and above (CGPA), the students shall be able to summarize the major, central tenets in their disciplines; this will provide ample chances for them to qualify for national eligibility tests and professional development gained will lead them to be successful in their careers in academia / industry. |

## Program Specific Outcome (PSO)

| | |
|---|---|
| PSO1 | **Enrichment of Knowledge:** This course is designed to provide and knowledge regarding Environment and Ecosystem, including an introduction of the major ecosystems, biomes, forests |
| PSO2 | **Thorough understanding:** Students will understand the role of native microbes, nutrient cycling in the segments of biosphere. |
| PSO3 | **Bioenergy overview:** Introduces the concept of bioenergy resources and its scenario in India and at global level |
| PSO4 | **Scientific information:** Gives adequate knowledge regarding the atmospheric chemical and photochemical reactions resulting in various impacts to the biosphere. |
| PSO5 | **In depth clarity:** Understand the importance and conservation perspectives of various natural resources and biological diversity. |
| PSO6 | **Application of acquired knowledge:** Describes the various types of pollution, impact on the environment and the approach to remove/reduce the air, soil, water, noise and other types of pollution. |
| PSO7 | **Decision making:** Learn the different instrumentation including molecular techniques, and how to use as an environmental analytical tool for environmental matrices. |
| PSO8 | **Mastering the techniques:** Know about the importance of Industrial safety in regional, national and global levels. |
| PSO9 | **Meeting SDG:** Understand the possibility of bioremediation, recycle, reuse, zero waste discharge, circular economy ensuring Sustainable development. |
| PSO10 | **Comprehend Regulations:** Identify the role of EIA in sustainable environment management before the Projects are implemented with an adequate knowledge regarding laws and Policies |

# BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024
## DEPARTMENT OF ENVIRONMENTAL BIOTECHNOLOGY
## M.Sc., Environmental Science (Program Code: 2PSEVS)
### Course Structure (CBCS)
*From Academic year 2025-2026 onwards*

| Semester | Sl. No | Course code | Course Title | Hrs/week | Credits | Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | IA | UE | Total |
| I | 1 | CC01 | Ecology and Environmental Sciences | 5 | 5 | 25 | 75 | 100 |
| | 2 | CC02 | Environmental Microbiology | 5 | 5 | 25 | 75 | 100 |
| | 3 | CC03 | Bio- Energy Resources | 4 | 4 | 25 | 75 | 100 |
| | 4 | CO01 | 1.Environmental Chemistry<br>2.Eco-Tourism | 5 | 5 | 25 | 75 | 100 |
| | 5 | EC01 | A.Biodiversity and Conservation<br>B. Natural Resources<br>C.Environmental Law and Policy | 4 | 4 | 25 | 75 | 100 |
| | 6 | LC01 | Laboratory course 1- Environmental Chemistry, Environmental Microbiology | 5 | 3 | 40 | 60 | 100 |
| | | | Seminar / Library / Leveraging E- resources | 2 | | | | |
| | | | Total | 30 | 26 | 165 | 435 | 600 |
| II | 7 | CC04 | Water, Soil Pollution & Management | 5 | 5 | 25 | 75 | 100 |
| | 8 | CC05 | Air pollution and its Management | 4 | 4 | 25 | 75 | 100 |
| | 9 | CC06 | Environmental Toxicology | 4 | 4 | 25 | 75 | 100 |
| | 10 | CO02 | 1.Environmental Analytical Methods<br>2. Industrial Health and Safety management | 4 | 4 | 25 | 75 | 100 |
| | 11 | EC02 | A.Environmental Impact Assessment<br>B.Disaster Management<br>C.Global Warming and Climate Change | 4 | 4 | 25 | 75 | 100 |
| | 12 | LC02 | Laboratory course -2- Water, Soil, Air Pollution & Management, Environmental Toxicology | 4 | 3 | 40 | 60 | 100 |
| | 13 | NMEC01 | Non-Major Elective** | 3 | 2 | 25 | 75 | 100 |
| | | | Seminar / Library / Leveraging E- resources | 2 | | | | |
| | | | Total | 30 | 26 | 190 | 510 | 700 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| III | 14 | CC07 | Solid & Hazardous Waste Management | 5 | 5 | 25 | 75 | 100 |
| | 15 | CC08 | Environmental Biotechnology | 4 | 4 | 25 | 75 | 100 |
| | 16 | CO03 | 1.Remote Sensing and GIS for Environmental Studies 2.Environmental Informatics | 4 | 4 | 25 | 75 | 100 |
| | 17 | EC03 | A.Biosafety and Bioethics B.Forest Ecology & Management C.Environmental Geosciences | 4 | 4 | 25 | 75 | 100 |
| | 18 | LC03 | Laboratory course 3- Remote Sensing and GIS for Environmental Studies | 4 | 4 | 40 | 60 | 100 |
| | 19 | EIBC01 | Bio Entrepreneurship | 4 | 3 | 25 | 75 | 100 |
| | 20 | CP01 | Project | 2 | | | | |
| | 21 | NMEC02 | Non-Major Elective** | 3 | 2 | 25 | 75 | 100 |
| | | | Total | 30 | 26 | 190 | 510 | 700 |
| IV | 22 | CP01 | Project | 30 | 12 | 25 | 75 | 100 |
| | | | Grand Total | 120 | 90 | 570 | 1530 | 2100 |

## Non Major Elective

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| II | NMEC01 | Contemporary Environmental Issues | 3 | 2 | 25 | 75 | 100 |
| III | NMEC02 | Energy and Environment | 3 | 2 | 25 | 75 | 100 |

## Extra Credit Courses

| Course Code | Title of the Course | Credits | Hours / week | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|
| | | | Theory | Practical | CIA | ESE | Total |
| **SEMESTER – I** | | | | | | | |
| VAC1 | Ecofriendly Products | 2 | 30 | - | 25 | 75 | 100 |
| **SEMESTER – II** | | | | | | | |
| ONC01 | SWAYAM/MOOC/NPTEL | 2 | - | - | - | - | - |
| FPI01 | Field Project / Internship# | - | - | - | - | - | - |
| **SEMESTER – III** | | | | | | | |
| VAC2 | Waste to Wealth | 2 | 30 | - | 25 | 75 | 100 |
| FPI02 | Field Project / Internship## | - | - | - | - | - | - |

***** **Optional Core Courses**

**** Value added courses not included for Credit Calculations**

**#** **Field Project/Internship - To undergo during the semester holidays (End of the semester - II)**

**##** **Field Project/Internship - To undergo during the semester holidays (End of the semester - III)**

*** SWAYAM – MOOC – Online course should be for the duration of at least 4 weeks with minimum of 2 credits. The course is mandatory and should be completed within the third semester (i.e., before the start of the fourth semester).**

## Program Summary

| Core Credit Courses | | | Extra Credit Courses | |
|---|---|---|---|---|
| Total Courses | Total Credits | Total Marks | Total Courses | Total Credits |
| **22** | **120** | **2100** | **5** | **6** |

***For final grading and ranking, only the core credit courses will be accounted. However, for the award of the degree, completion of all the extra-credit courses is mandatory***

## SEMESTER - I

### CORE I: ECOLOGY AND ENVIRONMENTAL SCIENCE

| Course Code | CC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 1 | - | 5 | | |
| Pre-requisite | Basic Knowledge about Ecology | | | | | | | | |

**Course Objectives:**

- *This course is framed in such a way that the students are exposed to the structure and function of our life-supporting environment*
- *It also provides the understand the causes effects and solutions for different environmental problems*

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The learner will understand the structure and function of our life-supporting environment the fundamentals of ecology | **K1, K2** |
| CO2 | Student would learn the basic concepts of population ecology and the interactions between the species | **K2, K4** |
| CO3 | One can clearly understand the interaction between the communities and the progression of ecological succession | **K2, K4** |
| CO4 | Student gains knowledge on the basic concepts of ecosystems and its components and the concepts of food chain, food web and energy flow in an ecosystem | **K1, K2** |
| CO5 | Student could have a wide knowledge regarding various types of pollution and gets exposure regarding major case studies around the globe related to different environmental issues | **K4,K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Fundamentals of Ecology*** | Definition, Principle, Branches and Scope of Ecology. Ecology as an inter-disciplinary Science. Origin of life and speciation and settlement. Ecological Factors: Abiotic – Physical and Chemical Factors: Soil, Air, Water, Temperature, pH, Humidity, Radiation, Wind, Pressure and Precipitation. Biotic – Limiting Factors. Species Interaction: Commensalism, Amensalism, Mutualism, Competition,Parasitism,Prey–Predator Relationship– Sedimentary Cycles (P, S, Fe), Gaseous Cycles (C, N, O) and Hydrological Cycle. Tools and techniques used in Ecological Research, including GIS, remote Sensing, and Simulation Models. |

| | |
|---|---|
| **Unit II**<br><br>***Population Ecology and Species interaction*** | Population – Definition, Characteristics, Population Density, Natality, Mortality, Age Distribution, Growth Patterns, Population Fluctuation, Population Equilibrium, Biotic Potentials, Population Dispersion, Regulation of Population. Concept of 'r' and 'k' species. Keystone species - Ecological Age Pyramids. Survivorship Curves and its Types. Population Growth Models (Exponential, Logistic), Population Regulation, and Life History Strategies. |
| **Unit III**<br><br>***Community Ecology and Ecological Succession*** | Community – Definition, Characteristics, Dominance, Structure, Stratification, Periodicity, Fluctuation within Community, Types and Interaction - Predation, Herbivory, Parasitism and Allelopathy Biological invasions. Communal Interdependence, Ecotone, Edge Effect, Ecological Niche and Ecological Equivalents, Ecological Succession- Primary and Secondary Succession, Mechanisms, and Stages,Types, Process, Climax and Significance of Succession.<br>. |
| **Unit IV**<br><br>***Ecosystem*** | Definition, Concept, Structure and Function of an Ecosystem: Producers, Consumers and Decomposers. Primary and Secondary Productivity. Food Chain, Food Web, Energy Flow. Ecological Pyramids – Types, Ecosystem Types: Terrestrial – Forest, Mountains, Deserts and Grassland. Aquatic – Freshwater (Lentic and Lotic) and Marine (Estuary, Deep sea) – Mangroves, Corals. Ecosystem stability and factors affecting stability. Ecosystem services. Ecological Niches: Fundamental and Realized Niche, Niche Partitioning, and Niche Construction. Biomes: Concept, classification and distribution. Characteristics of different biomes: Tundra, Taiga, Grassland, Deciduous forest biome, Highland Icy alpine biome, Chaparral, Savanna, Tropical Rain forest. |
| **Unit V**<br><br>***Introduction to Environmental Sciences*** | Definition, Principle and Scope of Environmental Sciences. Earth, Man and Environment Interactions. Geographical Classification and Zones – Torrid, Temperate and Frigid Zones. Significance of Atmosphere, Lithosphere, Hydrosphere and Biosphere. Environmental Pollution: Definition and Types (Air, Water and Soil). Case Studies – London Smog, Minamata Disease, Love Canal, Bhopal Gas Tragedy, Chernobyl Disaster, Torrey Canyon Oil spill. Fukoshima nuclear disaster, Seveso Dioxin Crisis- Biodiversity - Definition, Concept and Types |
| ***Current Contour*** | Recent scenario of Air and Water Pollution at national and global level – highly polluted cities. Various Ecosystems of Tamil Nadu, Threat to the coral reef, Impact of Tannery industries in and around Tiruchirappalli, Impact of Cement Industries. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | L | L | S | S | L | M | S | S | M |
| **CO2** | S | L | M | M | S | L | M | S | M | M |
| **CO3** | S | M | L | M | S | M | L | S | L | M |
| **CO4** | S | L | M | M | S | L | M | S | M | M |
| **CO5** | S | S | M | S | M | M | S | S | S | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. A Text-Book of Ecology, S. K. Dubey (2006), Dominant Publishers.
2. Ecology Principles and Applications, J. L. Chapman & M. J. Resiss (2010), Cambridge University Press.
3. Ecology, Russell (2008), Cengage Learning.
4. Elements of Ecology, Thomas M. Smith, Robert Leo Smith (2016), Pearson India Education Services.
5. Environment, Peter H. Raven, Berg, David M. Hassenzahl (2010), John Wiley & Sons.
6. Environmental Science Physical Principles and Applications, Egbert Boeker & Rienkvan Grandelle (2001), John Wiley & Sons.
7. Environmental Science, Travis Wagner & Robert Stanford (2005), John Wiley & Sons.
8. Fundamentals of Ecology, Eugene P. Odum, Gary W. Barrett (2012), Cengage Learning
9. Ricklefs, R. E. (2013). Ecology: The Economy of Nature (7th ed.). New York, NY: W.H. Freeman and Company.
10. Smith, T. M., and Smith, R. L. (2015). Elements of Ecology (9th ed.). Boston, MA: Pearson Education.
11. Odum, E. P., and Barrett, G. W. (2004). Fundamentals of Ecology (5th ed.). Belmont, CA: Brooks/Cole, Cengage Learning.
12. Gurevitch, J., Scheiner, S. M., and Fox, G. A. (2006). The Ecology of Plants (2nd ed.). Sunderland, MA: Sinauer Associates.
13. Gotelli, N. J. (2008). A Primer of Ecology (4th ed.). Sunderland, MA: Sinauer Associates.
14. Botkin, D. B., and Keller, E. A. (2014). Environmental Science: Earth as a Living Planet (9th ed.). Hoboken, NJ: Wiley.
15. Cunningham, W. P., and Cunningham, M. A. (2019). Principles of Environmental Science: Inquiry and Applications (9th ed.). New York, NY: McGraw-Hill Education.
16. Wright, R. T., and Boorse, D. F. (2013). Environmental Science (12th ed.). Boston, MA: Pearson Education.
17. Masters, G. M., and Ela, W. P. (2008). Introduction to Environmental Engineering and Science (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
18. Carson, R. (1962). Silent Spring. Boston, MA: Houghton Mifflin Harcourt.

**Related Online Contents:**

- http://www.envfor.nic.in
- http://www.ecology.edu

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**SEMESTER - I**

**CORE II: ENVIRONMENTAL MICROBIOLOGY**

| Course Code | CC02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 1 | | 5 | | |
| Pre-requisite | Knowledge about microorganisms of various segments of biosphere | | | | | | | | |

## Course Objectives:

- *This course provides a general introduction to the diverse roles of microorganisms in natural and artificial environments*
- *It also covers topics including: cellular architecture, energetics, growth, evolution, biogeochemical cycling and microorganisms involved in bioremediation.*

## Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The basics of Microbiology such as the types of microbes and their classification is taught | **K1** |
| CO2 | The identification of microbes using the basic and advanced tools is exposed to the students | **K2,K4** |
| CO3 | The metabolism involved in the microbial system is explained | **K3** |
| CO4 | The remediation of pollutants by microbes is emphasized | **K6** |
| CO5 | Application of microbes for sustainable environment is made to understand. Advanced molecular tools for the environment restoration are being emphasized | **K5,K6** |
| **K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation** | | |

| | |
|---|---|
| **Unit I**<br>***Microbial Taxonomy and Diversity*** | Classification and Taxonomy of Bacteria, Archaea, Eukaryotes-Fungi, Yeasts, Molds, Protozoa, Algae and Viruses. Molecular Approaches to Microbial Taxonomy - Phylogenetic Lineage of Microbes. |
| **Unit II** | Isolation, Cultivation and Preservation (Aerobic and Anaerobic), |

| | |
|---|---|
| ***Microbial Growth*** | Nutrient Media, Growth Curve, Mathematical Expression of Exponential Growth Phase, Measurement of Growth and Growth Yields, Synchronous Growth, Continuous Culture, Effect of Environmental Factors on Growth. Control of Microorganisms - Physical, Chemical and Antimicrobial Agents. |
| **Unit III**<br><br>***Microbial Metabolism*** | Energetics - Redox Reactions and Electron Carriers, An Overview of Metabolism – Anabolism / Catabolism, Central Metabolism - Glycolysis, Pentose - Phosphate Pathway, Entner-Docdoroff Pathway, Glyoxalate Pathway, Citric Acid Cycle, Fermentation, Aerobic and Anaerobic Respiration, Photosynthesis, Calvin Cycle. Metabolic Pathways of Contaminant Biodegradation, Metabolic Regulation, Stoichiometry and Bacterial Energetics - Mass Balances, Energy Balances (ΔG) – Growth, Substrate Partitioning and Theoretical Yield, Monod and Halden Kinetics. |
| **Unit IV**<br><br>***Microbial Degradation and Biotransformation*** | Xenobiotics – Recalcitrance and Persistence. Bioremediation – Types (*Insitu and Exsitu*), Advantages & Disadvantages; Biodegradation – Aromatic and Aliphatic Pollutants - Lignin, Pectin, Cellulose, BTEX, Phenols, PCB's, Dyes, Oil, Dioxins, Pesticides, Biotransformation – Heavy Metals (Cr, Ni, Fe). |
| **Unit V**<br><br>***Microbial Ecology and Applications*** | Sedimentary Biogeochemical Cycles – Fe, P and S, Gaseous Cycle – C, N and O, Soil Microorganisms Associated with Vascular Plants, Bioindicators, Biosensors, Biofertilizers, Biopesticides, Bioplastics, Bioleaching and Biomining, Biodeterioration and Biofuels. |
| ***Current contour*** | Microbial Genomics and Microbial Ecology; Genetic Exchange Gene Transfer; Introductory Bioinformatics - Data Analysis, Culture Based and Culture Independent Tools; Molecular Biology Tools - Cloning, Amplification, Sequencing with a Case Study. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | M | S | S | S | M | S |
| **CO3** | S | S | M | M | S | S | M | S | M | S |
| **CO4** | S | S | M | S | S | S | M | S | M | S |
| **CO5** | S | S | M | S | S | S | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Microbiology, K. J. Pelzer, E. C. S. Chan & N. R.Kreig (2008), Tata Mcgraw.
2. Environmental Biotechnology Principles and Applications, Bruce. E. Rittmannn (2001), Graw-Hill Book Co
3. Environmental Microbiology, John F. T. Spencer & A. L. R. Spencer (2004), Humana Press.
4. Microbiology, Jacquelyn G. Black (2008), John Wiley & Sons.
5. Environmental Microbiology, Ralph Mitchell & J. I. Dong Gu (2010), Wiley Blackwell.
6. The Dictionary of Environmental Microbiology, Linda D. Stetzenbach & Martylynn V. Vates (2004), Academic Press.
7. Microbiology, Alcamo I. Edward (2009), Tata McGraw- Hill.
8. Brock Biology of Microorganisms, Michael T. Madigan and John M. Martinko (2006), Prentice-Hall Inc.


## Related Online Contents:

- http://www.genomic.org.uk/history-of-genomics.html
- https://www.ncbi.nlm.nih.gov/pubmed/25422435
- https://www.ncbi.nlm.nih.gov/pubmed/20553550
- https://link.springer.com/chapter/10.1007/978-3-319-16345-1_6

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**SEMESTER - I**

**CORE III: BIO-ENERGY RESOURCES**

| Course Code | CC03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Knowledge about necessity of renewable energy resources | | | | | | | | |

## Course Objectives:

- *The students will be exposed to different types of energy resources and to the global energy budget*
- *Also they will be able to widen their knowledge in different types of wastes material from which energy can be derived and the energy patterns of India and world.*
- *To understand the fundamentals and significance of bioenergy.*
- *To explore different types of bioenergy resources and technologies.*
- *To evaluate the environmental and socio-economic impacts of bioenergy.*
- *To gain knowledge of bioenergy policies and future trends in the bioenergy sector*

## Expected Course Outcomes:

## On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand about the bioenergy consumption patterns & its growing need | **K1,K2** |
| CO2 | Know the types of bio energy resources | **K2** |
| CO3 | Acquire knowledge about the biofuels their production & methods of storage | **K4,K5** |
| CO4 | Understand the environmental impacts of bioenergy on the segments of biosphere | **K6,K7** |
| CO5 | Describe the applications of alternative energy resources. Case studies pertaining to bioenergy resources are also listed | **K4,K5** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Introduction to Bioenergy*** | Definition and Importance of Bioenergy-Sources of Bioenergy: Biomass, Biogas, Biofuels, Algae, Waste-to-Energy-Properties of Biofuels: Chemical Composition, Energy Content, Combustion Properties-Traditional vs Modern Bioenergy: Traditional Use of Biomass (Firewood, Charcoal), Modern Technologies (Bioethanol, Biodiesel, Biomass Gasification)-Bioenergy Consumption Patterns: Global and Regional Perspectives (with focus on developing countries). |
| ***Biomass resources and feedstocks*** | Types of Biomass: Agricultural Residues, Forest Residues, Municipal Solid Waste, Energy Crops (Miscanthus, Switchgrass), Algae-Biomass Harvesting, Collection, and Transportation-Sustainability of Biomass Resources: Land Use, Water Consumption, Biodiversity Impacts-Challenges in Biomass Availability: Seasonal Variations, Logistics, Storage-Case Studies: Biomass Utilization in India, Brazil, and the U.S. |

| | |
|---|---|
| **Unit III**<br>***Bioenergy Conversion Technologies*** | Thermochemical Conversion: Combustion, Pyrolysis, Gasification, and Torrefaction-Biochemical Conversion: Anaerobic Digestion, Fermentation, Transesterification for Biodiesel Production-Biogas Production: Feedstock, Process Design, Digester Types, and Upgrading Technologies-Biohydrogen Production: Methods, Applications, and Challenges-Bioenergy Systems: Small-Scale and Large-Scale Systems, Co-generation, Bio-refineries |
| **Unit IV**<br>***Environmental Impacts and Benefits of Bioenergy*** | Environmental Benefits: Reduced Carbon Emissions, Waste Management, Soil Improvement-Life Cycle Analysis (LCA) of Bioenergy Systems: Carbon Footprint, Energy Payback-Potential Environmental Concerns: Deforestation, Water Use, Pollution from Processing-Bioenergy and Climate Change: Role in Reducing Greenhouse Gas Emissions, Bioenergy with Carbon Capture and Storage (BECCS)-Sustainability Criteria for Bioenergy: Global Standards and Certification |
| **Unit V**<br>***Bioenergy Policy, Economics, and Socio-Economic Impacts*** | Global Bioenergy Policies: European Union's Renewable Energy Directive, U.S. Renewable Fuel Standard, and India's National Biofuel Policy-Incentives for Bioenergy: Subsidies, Carbon Credits, Feed-in Tariffs-Bioenergy Economics: Cost of Biofuel Production, Market Dynamics, Financial Viability-Social Impacts of Bioenergy: Energy Access in Rural Areas, Job Creation, Food vs. Fuel Debate-Case Studies of Successful Bioenergy Programs: Brazil's Ethanol Program, India's Biogas and Biomass Energy Initiatives |
| ***Current Contour*** | Improved Biomass Energy Technologies – Benefits and Challenges – The Kenya Ceramic Jiko – Smokeless chulkas – Bagasse-based co-generation - Synthetic Biology for Biofuel Production-Bioenergy with Carbon Capture and Storage (BECCS): Technology Overview and Potential-Decentralized Bioenergy Systems: Mini-grids, Off-grid Bioenergy Solutions for Rural Electrification-Future Challenges and Opportunities: Scaling Up Bioenergy -Emerging Markets for Bioenergy: Trends in Biofuel Trade and International Cooperation |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | M | L | L | M | L | S | M | S | S |
| **CO2** | M | L | L | L | S | M | M | S | L | L |
| **CO3** | S | S | S | M | S | M | S | S | S | M |
| **CO4** | L | M | M | L | L | M | S | M | S | L |
| **CO5** | S | S | M | L | L | L | S | M | S | L |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Renewable Energy Resources, Twidell J, Weir T (2015), Routledge
2. Renewable Energy, Sorensen B. (2010); Fourth Edition, Academic press
3. Introduction to Bioenergy (Energy and the Environment), Vaughn C. Nelson and Kenneth L. Starcher (2016), CRC Press, New Delhi.
4. Biomass to Biofuels, Anju Dahiya (2014), Academic Press,UK
5. Principles and Applications, Yebo Li and Samir Kumar Khanal (2016), Wiley Blackwell Pub.
6. Bioenergy, Judy D. Wall and Caroline S. Harwood, (2008) ASM Press, USA
7. Bioenergy: Sustainable Perspectives, Ted Weyland (Ed), (2016), Callisto Reference Pub.
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9. Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. Samir K. Khanal. (2008) Wiley-Blackwell Publishing.
10. Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean Philippe; Zaccour, Georges (Eds.), (2005), Springer.
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19. Cherubini, Francesco (2010). The Biorefinery Concept: Using Biomass Instead of Oil for Producing Energy and Chemicals. Energy Conversion and Management, 51(7): 1412-1421.
20. IEA Bioenergy (2017). Sustainable Bioenergy: A Framework for Decision Makers. International Energy Agency.
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22. Tilman, David, et al. (2009). Beneficial Biofuels—The Food, Energy, and Environment Trilemma. Science, 325(5938): 270-271.


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- Demirbas, A. (2009). *Biofuels: Securing the Planet's Future Energy Needs*. London, UK: Springer. https://link.springer.com/
- Luque, R., & Clark, J. H. (Eds.). (2010). *Handbook of Biofuels Production: Processes and Technologies*. Oxford, UK: https://www.sciencedirect.com/

- Brown, R. C. (2011). *Thermochemical Processing of Biomass: Conversion into Fuels, Chemicals, and Power*. Hoboken, NJ: John Wiley & Sons. https://onlinelibrary.wiley.com/
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- Van Loo, S., & Koppejan, J. (Eds.). (2008). *The Handbook of Biomass Combustion and Co-firing*. London, UK: Earthscan. https://www.researchgate.net/
- Kalia, V. C. (Ed.). (2016). *Microbial Applications Vol.1: Biofuels, Waste Treatment, and Nanobiotechnology*. Cham, Switzerland: Springer. https://link.springer.com/


**Related Online Contents:**

- http://www.eesi.org/
- www.energy.gov
- www.reenergyholdings.com
- http://www.wgbn.wisc.edu/
- http://www.fao.org/
- www.renewableenergyworld.com
- https://bioenergyinternational.com
- https://www.irena.org
- https://www.energy.gov/eere/bioenergy/bioenergy-technologies-office
- https://www.nrel.gov/
- https://bioenergyeurope.org/

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**SEMESTER - I**

**CORE OPTIONAL 1: ENVIRONMENTAL CHEMISTRY**

| Course Code | CO01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 1 | | 5 | | |
| Pre-requisite | Basics of Environment and chemistry | | | | | | | | |

**Course Objectives:**

- *To study the chemicals and chemical processes within the air, water and soil ecosystems*
- *And to impart the source, route, transformation and the effects of the chemicals on various ecosystems.*

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand the basic concepts of general chemistry | **K1** |
| CO2 | Know about various environment related chemical reactions | **K2** |
| CO3 | Gain knowledge regarding aquatic chemistry and reactions | **K2,K3** |
| CO4 | Acquire information regarding chemistry of atmosphere | **K2,K3** |
| CO5 | Describe the various chemical reactions of lithosphere. Have an idea regarding chemical reactions taking place in all segments of biosphere | **K4,K5** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Fundamental Concepts of General Chemistry*** | Concepts and Scope of Environmental Chemistry, Elements and Compounds - Atomic Structure, their Properties, Electronic Configuration, Types of Chemical bonds (ionic, covalent, coordinate and hydrogen bonds). Formation of Molecules, Molecular Weight, Equivalent Weight, Strength of the Solution – Molality, Molarity, Normality, Valency and Oxidation State, Oxidation and Reduction Reactions, Properties of Metals and Non-metals, Aromatic and Aliphatic Compounds, Saturated and Unsaturated Hydrocarbons, Radionuclides, Polarity of the Functional Groups. |
| **Unit II**<br>***Chemical Equilibrium and Kinetics*** | Stoichiometry, Chemical Equilibrium, Gibbs Energy, Chemical Potential, Acids, Bases and Salts, Acid-Base Reactions, pH and pOH, Ionic Product of Water, Solutions and solubility- Common Ion Effect, Buffer Solutions, Solutes and Solvents; Solubility and Solubility Product, Hydrolysis - Oxidation and Reduction, Chemical Speciation. Exothermic and Endothermic Reactions, Spontaneous and Nonspontaneous reactions. |

| | |
|---|---|
| **Unit III**<br>***Hydrospheric Chemistry*** | Chemistry of Water-Water structure and Properties, Water a s a Solvent- Water Quality Parameters - Physical, Chemical and Biological Properties of Water and their Environmental Significance- Methods of Water Quality Assessment-Distribution of Chemical Species in Water; Gases, Organic Matter and Humic Matter in Water. Heavy metals in water-Sources, solubility,toxicity and env. Impact of Hg, Cr(VI),Al Metal Solubility, Complexation and Chelation in Natural and Waste Water, Role of Microorganisms in Aquatic Chemical Reactions-Nutrient cycling(N,P), degradation of organic pollutants(PAH,Phthalates) |
| **Unit IV**<br>***Atmospheric Chemistry*** | Structure and Composition of Atmosphere, Classification of Elements, Particulate Matter, Ions and Radicals in the Atmosphere- Formation and Role of Free Radicals (OH, NO3, etc.) Ionization Processes in the Atmosphere. Chemical and Photochemical Reactions in the Atmosphere - Formation of Smog, PAN, Aerosols; Chemistry of Acid Rain and its impacts on Soil water bodies and vegetation- Reactions of $NO_2$ and $SO_2$. Oxygen and Ozone Chemistry- Ozone Layer and Its Importance, Ozone Depletion Reactions, Role of CFCs and Halogens in Ozone Depletion. |
| **Unit V**<br>***Soil Chemistry*** | Soil Profile, Soil Horizons, Physical, Chemical and Biological Characteristics of Soil, Nature of Soil, Soil Structure and Texture. Soil Macro and Micro Nutrients, Soil Water and its types, Soil Air, Soil Temperature, Soil Organic Matter. Soil Colloids, Ion Exchange Capacity. Inorganic and Organic Components of Soil, Anion and Cation Exchange Reactions in Soil, Nitrogen Pathways and NPK in Soils. |
| ***Current Contour*** | Ocean Microplastics Contamination- Sources and Types of Microplastics in the Ocean, Environmental and Ecological Impacts of Microplastics, Microplastic Bioaccumulation in Marine Life, Role of Microbes in Breaking Down Plastics in Oceans,Potential of Biodegradation for Reducing Plastic Pollution Applications of Plastic-Degrading Enzymes in Waste Management-Strategies for Monitoring and Reducing Microplastic Pollution, Arsenic Sensing and Removal Strategies, Toxins in Fracking Fluid. |

**Mapping with Programme Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | M | S | S | S | S | S |
| **CO2** | S | S | M | S | M | S | S | S | S | S |
| **CO3** | S | S | M | S | S | S | S | M | M | M |
| **CO4** | S | S | M | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | M | M | M | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Basic Concept of Environmental Chemistry, Des W. Connell (2005), Taylor & Francis
2. Environmental Chemistry with Green Chemistry. Asim K. Das & Mahua Das (2012), Books & Allied Pvt. Ltd.
3. Environmental Chemistry, A. K. De (2010), New Age International Pvt. Ltd.
4. Environmental Chemistry, Colin Baird & Michael Cann (2008), W. H. Freman & Co.
5. Environmental Chemistry, Stanley E. Manahan (1999), CRC Press
6. Environmental Science & Technology, Stanley E. Manahan (2007), Tailor & Francis, CRC Press
7. Fundamentals Concepts of Environmental Chemistry, G. S. Sodhi (2011), Narosa Publishing House
8. The Principles of Environmental Chemistry (3rd edition), James E. Girard (2013), Jones & Bartlett,USA.
9. Manahan, S. E. (2017). Environmental Chemistry (10th ed.). Boca Raton, FL: CRC Press.
10. VanLoon, G. W., and Duffy, S. J. (2011). Environmental Chemistry: A Global Perspective (3rd ed.). Oxford, UK: Oxford University Press.
11. Baird, C., and Cann, M. (2012). Environmental Chemistry (5th ed.). New York, NY: W.H. Freeman and Company.
12. Connell, D. W. (2005). Basic Concepts of Environmental Chemistry (2nd ed.). Boca Raton, FL: CRC Press.
13. Harrison, R. M. (Ed.). (2007). Principles of Environmental Chemistry (2nd ed.). Cambridge, UK: Royal Society of Chemistry.
14. Spiro, T. G., and Stigliani, W. M. (2003). Chemistry of the Environment (2nd ed.). Sausalito, CA: University Science Books.
15. Rao, C. S. (2007). Environmental Pollution Control Engineering. New Delhi, India: New Age International Publishers.
16. Alloway, B. J., and Ayres, D. C. (1997). Chemical Principles of Environmental Pollution (2nd ed.). Dordrecht, Netherlands: Springer.


**E-BOOKS**


- http://base.dnsgb.com.ua/files/book/Agriculture/Soil/The-Chemistry-of-Soils.pdf
- http://www.ncert.nic.in/ncerts/l/kech101.pdf
- Srivastava, S. Environmental Chemistry. https://ndl.iitkgp.ac.in/
- Lancaster, M. Introduction to Green Chemistry. Green Chemistry Network Centre, University of Delhi.: http://www.du.ac.in/du/uploads/centres_institutes/green_chemistry/ebook.pdf
- Saleh, H. E. D. M. (Ed.). Chemistry for Sustainable Development. IntechOpen. https://www.intechopen.com/books/chemistry-for-sustainable-development
- Patnaik, P. Handbook of Environmental Analysis. https://openlibrary.org/

**Related Online Contents:**

- https://www.khanacademy.org/science/chemistry
- https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/lecture-notes/
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-84j-atmospheric-chemistry-fall2013/lecture- notes
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-89-environmental-microbiology-fall2004/lecture-notes/
- https://www.rsc.org/journals-books-databases/about-journals/environmental-science/
- American Chemical Society (ACS)
- https://pubs.acs.org/journal/esthag
- https://www.niehs.nih.gov/health/topics/index.cfm
- https://www.epa.gov/
- https://www.sciencedirect.com/journal/environmental-chemistry-and-ecotoxicology

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**SEMESTER - I**

**CORE OPTIONAL 2: ECO TOURISM**

| Course Code | CO01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 1 | | 5 | | |
| Pre-requisite | Knowledge regarding Environment and tourism | | | | | | | | |

## Course Objectives:

- *This course introduces the students to the economic, cultural and environmental impacts of ecotourism*
- *The students will also be aware of different Eco tourist spots*
- *They will be also prepared to analyze and understand ecotourism as a significant aspect of tourism in the mere future.*

## Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand the basic principles and practices of eco-tourism | **K1** |
| CO2 | Understand the ecotourism spots | **K2** |
| CO3 | Know about the importance of ecotourism and the methods of conservation | **K4** |
| CO4 | Explain the factors that pose an impact on ecotourism | **K7** |
| CO5 | Students would be aware of various ecotourism spots | **K6** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I** ***Introduction to Tourism and Ecotourism*** | Concepts of Tourism – Classification of Tourism – Religious – Cultural – Heritage – Monumental – Adventure – Mass – Sustainable – Consumptive and Non - Consumptive Tourism. Introduction to Ecotourism – Concepts, History and Origin - Objectives and Benefits of Ecotourism – Factors Affecting Ecotourism. |

| | |
|---|---|
| **Unit II**<br>***Ecotourism Spots*** | Places of Interests of Ecotourism – Eco circuit of the Eastern and Western Ghats (India) – Infrastructural Facilities for Ecotourism – Maintenance of Ecological Centers – Important Biosphere Reserves. Target Group of Ecotourism. **Economic Dimensions:** Ecotourism as a Tool for Development, Challenges of Economic Sustainability, Green Marketing and Certification. |
| **Unit III**<br>***Ecotourism, Types and Conservation*** | Types of Ecotourism – Rain forest – Mountain, Polar, Islands and Coasts – Wilderness – Total Quality Management (TQM) of Ecotourism Resorts, Knowledge, Skills, Attitude and Commitment of Ecotourism Service Providers. Biodiversity Conservation and Sustainable Ecotourism, Community. Based Tourism for Conservation and Development. Conservation – *In situ* and *Ex situ* (Sanctuaries, National Parks, Gene Banks, Seed Banks, Ova Bank). Oslo Declaration 2007. Protected Area Management through Ecotourism - Stakeholder Engagement - Community Participation - Types of Participation, Issues and Challenges - Ecotourism Projects. |
| **Unit IV**<br>***Impact of Ecotourism*** | Economic Impacts (Fiscal Impacts, Concept and Methods) – Types and Degree of Impacts from Ecotourism activities – Socio - Cultural Impacts – Ecotourism Related Organization – Ecotourism Research- Disasters and Ecotourism – Role of Ethics in Ecotourism – Advantages and Limitations of Ecotourism – Eco - Branding, Green Washing and Eco-labeling of Ecotourism Products – Marketing of Ecotourism, Ecotourism and Sustainable Development – Management Issues in Ecotourism, Ecotourism Based/Related Employment, Scope and Areas of Employment. |
| **Unit V**<br>***Case Studies of Ecotourism*** | Case Study – Parambikulam Tiger Reserve, Kaziranga National Park, Ecotourism Spots in Tamil Nadu (Ooty, Kodaikanal, Elagiri, Yerkaud). A World Heritage Site in Assam, Ecotourism in Bagalkot District, Karnataka, The Kabini River Lodge, Fambong Lho Wildlife Sanctuary, Sikkim– Ecotourism Potential in Tripura, North East India. Case Studies fromHainan, China. Ecotourism Development Agencies- Role of the International Ecotourism Society - the UNWTO, UNDP, WWF - Department of Forest and Environment - Government of India, ATREE, EQUATIONS. |
| ***Current Contour*** | Virtual Ecotourism, *Leishmaniasis* Transmission in an Ecotourism Area of Brazil. SWOT Analysis of Ecotourism. |

**Mapping with Programme Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | S | S | S | M | M |
| **CO2** | S | M | M | M | S | M | S | M | S | M |
| **CO3** | M | S | S | S | M | M | S | S | S | S |
| **CO4** | S | M | S | M | M | S | S | S | M | M |
| **CO5** | M | L | M | S | S | S | M | M | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Case studies in ecotourism, Buckley, R. (2003), Cambridge CABI Pub.
2. Ecotourism and sustainable Development, Ravi Shankar Kumar Singh (2003). Abhijeet Publications, New Delhi.
3. Ecotourism Impacts, Potentials and Possibilities, Wearing and Neil (2000), Oxford: Butterworth & Heinemann.
4. Ecotourism, Page, S.J. and R.K. Dowling. (2002). New York: Prentice Hall.
5. Ecotourism. An Introduction, Fennell A David. (2003), Routledge, London and New York.
6. Encyclopaedia of Ecotourism, Volume I, II and III, Sinha, P.C (2003), Anmol Publications Pvt. Ltd.,
7. Environmental impacts of ecotourism, Buckley, R. ed. (2004), Oxfordshire: CABI.
8. Environment Impacts of Ecotourism, Ralf Buckley (2004), CABI, London.
9. The Encyclopedia of Ecotourism, Weaver, D. (2001), Cabi Publication.
10. Ecotourism Policy and Planning, Fennel, D. A. (2002), Cabi Publishing, Usa.
11. Cultural, Ecology and Sustainable Development, Sukanta K Chaudhury, Mittal, Delhi.


## Related Online Contents:

- http://www.ecotourism.org/news/category/internet-technology/
- https://parasites andvectors.biomedcentral.com/articles/10.1186/ 1756-3305-6-325
- http://media.unwto.org/press-release/2013-01-03/un-general-assembly-ecotourism-keyeradicating-poverty-and-protecting- envir
- http://sdt.unwto.org/content/ecotourism-and-protected-areas
- http://tourism.gov.in/eco-tourism

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**SEMESTER – I**

**Elective A: BIODIVERSITY AND CONSERVATION**

| Course Code | EC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Knowledge on importance of Biodiversity | | | | | | | | |

## Course Objectives:

- *This course deals with biodiversity conservation which is a major domain of Environmental Science*
- *On completion of the course the student learns about the different aspects of diversified ecosystem, its deterioration, conservation and management strategies to be adopted in changing global scenario.*

## Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Students would understand the types of biodiversity | **K1, K2** |
| CO2 | The learner will know about the economic values of loss of biodiversity and One could obtain the knowledge of sustainable environment | **K5** |
| CO3 | The importance and threats to biodiversity is taught and One could learn about the methods followed for Biodiversity Conservation. | **K4, K7** |
| CO4 | Students are taught about the acts, protocols, and conventions regarding the biodiversity conservation | **K5** |
| CO5 | Students get exposed to the status of endangered, extinct, rare species of India and of the world. | **K6, K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Introduction and Types of Biodiversity*** | Definition and Scope of Biodiversity - Composition and Scales of Biodiversity: Types of Biodiversity: Genetic Diversity, Species Diversity, Ecosystem Diversity, Landscape/ Pattern Diversity, Importance of Biodiversity, Threats to Biodiversity-Natural and Anthropogenic, Conservation Strategies, Concept and basis of identification of 'Hotspots'; hotspots in India. |

| | |
|---|---|
| **Unit II**<br>***Status of Biodiversity*** | Biogeographical Classification in India. Status of Biodiversity – Global, National and Local Status. Species Inventory, Hot-spots of Biodiversity. Concept of restoration ecology. Extinct, Rare, Endangered and Threatened flora and fauna of India. Bioprospecting, IUCN Categories – Red Data Book- Biodiversity and Climate Change, Policy and Biodiversity Conservation. |
| **Unit III**<br>***Values of Biodiversity*** | Ecological Value, Cultural Values, Economic Valuation of Biodiversity, Direct, Indirect/ Non-consumptive Use Value – Tangible Benefits - Food, Fiber, Fodder, Timber, Rattans and Canes, Ornamentals, Medicines and Construction Material. Intangibles - Pollination, Pest Control, Soil Development and Maintenance of Soil Fertility, Soil and Water Conservation. Environmental Ethics. Intrinsic Value; Ethical and Aesthetic, Anthropocentrism, Biocentrism, Ecocentrism and Religions; Intellectual Values |
| **Unit IV**<br>***Loss of Biodiversity*** | Major Drivers of Biodiversity Loss -Habitat Alteration, Invasive Species, Pollution, Population Explosion, and Over Exploitation of Bioresources - Factors Causing Loss of Genetic Diversity- Loss of Species Diversity- Processes Responsible for Species Extinction, Current and Future Extinction Rates, IUCN Threatened Categories, Sixth Extinction/Biological Crisis. Loss of Ecosystem Diversity - Factors Affecting Ecosystem Diversity, Loss Diversity of Major Ecosystem - Loss of Agrobiodiversity - Projected Scenario for Biodiversity Loss - Loss of Biodiversity as and Economic Process- Policy and Legislation, Future Directions and Solutions. |
| **Unit V**<br>***Biodiversity Conservation*** | Introduction to Biodiversity and Conservation, Protection of Natural Habitats, National and International Protected Area, Current Practices in Conservation - In Situ Conservation and Ex Situ Conservation of Threatened Species - Cryopreservation, Gene Banks, Gene Pool and Species Conservation. National Parks and Sanctuaries. Economic Aspects of Conservation, Community-Based Conservation, The Biological Diversity Act, 2002, Biological Diversity Rules, 2004–Patent Act-Intellectual Property Rights (IPR). Biodiversity Bill 2002, Agenda 21, Biodiversity Conventions, Case Studies in Biodiversity Conservation. |
| ***Current Contour*** | For an assessment of biodiversity, a field visit to BDU campus. Field visit to Butterfly Conservation Park. An observation visits to Pachamalai area, Trichy. To study about marine bio-resources (MFR) |

**Mapping with Programme Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | S | M | S | M | S | S | M | M | S |
| **CO2** | S | M | S | M | S | M | S | S | M | M |
| **CO3** | S | S | M | L | S | M | M | M | S | S |
| **CO4** | M | M | S | M | M | M | M | S | M | M |
| **CO5** | S | S | M | S | S | S | M | M | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |


1. Sustaining Life: How Human Health Depends on Biodiversity edited by Eric Chivian and Aaron Bernstein (2008). Oxford Academic Press.
2. Biodiversity and Human Health, Aguirre, A. Alonso (2009), Eco Health, 6 (1), 153-156.
3. Biodiversity and Ecosystem functioning, Michael Lotaceer, Shaheed Naeen & P. Inchausti (2002). Oxford Press.
4. Environmental Biodiversity, P. R. Yadhav, Shudrata. R. Mishra (2004), Discovery Publishers.
5. Valuation and Conservation of Biodiverstiy, M. Markassen, R. Buse & H. Garrelts (2005), Springer.
6. Biodiverstiy, Supriyo Chakraburty (2007), Pointer Publishers.
7. Global Biodiversity and Environmental Conservation, T. I. Khanz (2000) Oxford Press.
8. An Introduction to Conservation Biology (2nd ed., annotated), Sher, A. A., & Primack, R. B. (2020). Oxford University Press.
9. Biodiversity and Health in the Face of Climate Change by Melissa R. Marselle, Jutta Stadler, Horst Korn, Katherine N. Irvine, and Aletta Bonn (2019). Springer.


**WEBLINK**

- www.biodiversityofindia.org
- www.edu.green.teri.res.in
- www.intelwl.org
- www.glems.com

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## SEMESTER: I

**Elective B: NATURAL RESOURCES**

| Course Code | EC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Knowledge about different natural resources | | | | | | | | |

### Course Objectives:

- *This course explains about the natural resources in environment which influences the quality of life, and the functioning of natural environment*
- *The course is designed to understand the importance of resources in the nature.*

### Expected Course Outcomes:

**On the completion of the course the student will be able to**

| Cos | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The learner would acquire knowledge regarding the water resources as a natural resource | **K1,K2** |
| CO2 | The importance of mineral resources was explained to the learners | **K2** |
| CO3 | The soil and its degradation was clearly explained and would be taught | **K3** |
| CO4 | The importance of forests for the resources they provide was explained in detail | **K4** |
| CO5 | The case study was included to give a better understanding. The importance of natural resources and the need to preserve them was well explained | **K6,K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Water Resources*** | Origin and Composition of Water – Hydrological Cycle, Properties of Water, Types and Characteristics of Water Bodies, Human Use of Surface and Ground Water, Fresh Water and Marine Water Resources. Watershed Management, Conservation of Water Resources – Rain Water Harvesting System, Water Storage Systems and their Importance. |
| **Unit II**<br>***Mineral Resources*** | Minerals on the Geosphere, Types of Minerals, Extraction, Mining - Metal and Non - Metal Resources, Exploitation of Mineral Resources, Environmental Effects of Extraction and Use of Mineral Resources, Case Study: Dehradun – Missouri Mine Belt. |
| **Unit III**<br>***Land Resources*** | Introduction to Land Resources and their Types. Land Degradation and Soil Erosion - Causes and Impacts - Desertification, Deforestation, Land Contaminants and their Effects, Waste Land Reclamation. |
| **Unit IV**<br>***Forest Resources*** | Forest Types and their Resources, Carbon Sequestration, Use and Over-Exploitation – Timber and their Resources, Effects on Forest and Tribal People – High Conservation Value Forest – Plantation, Social and Cultural Forest, Sustainable Management. Wildlife Resources **i**mportance of biodiversity. Threats to wildlife and conservation strategies. Protected areas and wildlife corridors. Carbon Sequestration: Forests act as significant carbon sinks, absorbing carbon dioxide from the atmosphere during photosynthesis and storing it in biomass and soil. |
| **Unit V**<br>***Agricultural resources*** | World Food Problems, Changes Caused by Agricultural Practices and Over Grazing, Effects of Modern Agriculture, Fertilizer and Pesticides Problems, Water Lodging, Salinity, Livestock Resource Livestock's Resource in India an Overview. Approaches in Resource Management: Ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies. |
| ***Current Contour*** | Food and drink, Mobility, Housing and infrastructure, Natural Resource Economics, Externalities and Impacts on Resource Allocation, Conservation, Preservation, Exploitation of Natural Resources. Perceptions of Natural Resources, Ecology, Biomes-Management of Common International Resources: Ocean, climate, International fisheries and management commissions; Antarctica: the evolution of an international resource management regime. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | M | S | S | S | S | M | M | M | M |
| **CO2** | S | S | S | S | M | M | M | M | S | S |
| **CO3** | S | S | M | M | M | S | S | S | M | M |
| **CO4** | M | M | M | S | M | S | M | S | M | S |
| **CO5** | S | S | S | S | M | M | M | S | S | S |

**S-Strong; M-Medium; L-Low**

## Recommended References:


1. Environmental Encyclopedia, Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. (2001) , Jaico Publishing House.
2. Text book of Environmental Studies, Eranch Bharucha (2005), Universities Press.
3. Environmental Studies, Kumarasamy K, Alagappa Moses A and Vasanthy M (2004), Bharathidasan University Publishers.
4. Environmental Science and Technology, Stanley E. Manahan (2007), Taylor & Francis, CRC Press.
5. Instant notes Ecology, Aulay Mackenzie, Andy S. Ball and Sonia R. Virdee (2002), Bios Scientific Pub. Ltd.,
6. Environmental Science, Physical Principals and Application, Egbert Boeker and rienk van Grondelle (2001), John Wiley & Sons.
7. Environmental Science, Santra, S.C (2005), New Central Book Agency (P) Ltd.,
8. Forest Economics and Management, Sharma, L.C (1998), M/S Bishen Singh Mahendrapal Singh, Dehradun.
9. Reports by UN Environment Programme (UNEP) and Intergovernmental Panel on Climate Change (IPCC).


## Related Online Contents:

- http://library.umac.mo/ebooks/b28112672.pdf
- https://books.google.co.in/books?id=Tz9iDM6crLIC&printsec=frontcover#v=onepage&q&f=false
- http://library.umac.mo/ebooks/b28112672.pdf
- https://books.google.co.in/books?id=ZgtiB3VRsMC&printsec=frontcover#v=onepage&q&f=false
- https://books.google.co.in/books?id=TZoAAAAAQBAJ&printsec=frontcover#v=onepae&q&f=false

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## SEMESTER - I

**Elective C: ENVIRONMENTAL LAW AND POLICY**

| Course Code | EC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Basic knowledge of Environmental protection | | | | | | | | |

### Course Objectives:

- *To make students aware of Indian as well as International environmental laws and their importance.*
- *To develop an ethical consideration to environment and its components*

### Expected Course Outcomes:

**On completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Familiar with the laws acts in the field of Environment | **K1** |
| CO2 | Acquire knowledge regarding international environmental treaties | **K2** |
| CO3 | Understand the Policies, regulations work to Environmental protection | **K3** |
| CO4 | Gets on exposure to SDG's the current topic | **K4,K5** |
| CO5 | Can realize the importance of Environmental ethics and its impact. Acquire the ability to know about the laws, policies | **K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Environmental Laws in India*** | Environmental Policy and Laws. Constitutional and Statutory laws in India: Doctrine Principles of State Policy, Fundamental duties and Fundamental Rights and Panchayat Raj System, Statutory protection of the Human environment: such as Indian penal court, Factories Act, Motor Vehicle Act, Hazardous waste legislation for pollution abatement. Anti-Pollution Acts: The Water Act, 1974, The Air Act, 1981.The Environment Protection Act 1986.Objectives of the Anti-Pollution Acts. |

| | |
|---|---|
| **Unit II**<br><br>***International Environmental Treaties*** | Evolution and Development on International Environmental Laws with references to Stockholm Conference 1972, Nairobi Declaration 1987, Rioconference,1992, Rio+5, Rio+10 Environmental issues and international laws: to control Global warming, Ozone depletion, Acid rain, hazardous waste, CITES Role of UN authorities in Protection of Global Environment, Multinational authorities and agreements, future of international laws. |
| **Unit III**<br>***National Environmental Policy and Regulatory frame work*** | National Policy on EIA and Regulatory Framework: Rule & Regulation of Central & Sate Government and Pollution Control Boards for safeguard for Environmental Protection. Wildlife Protection Act, 1972 amended 1991, Forest Conservation Act, 1980; Indian Forests Act revised1982; Air (Prevention and Control of Pollution) Act 1981 as Amended by Amendment Act1987 and rule1982. Scheme of labeling of environmentally friendly products (Ecomark), Public liability Insurance Act, 1991 and Rules 1991.Provision of Constitution of India regarding Environment (Article48Aand 58A). |
| **Unit IV**<br><br>***Sustainable Development*** | Definition and concepts of Sustainable development, Integration of: Economic, Social and Environmental sustainability, Biodiversity and Availability of natural resources in development. Sustainable development scenario-global and national level. Sustainable development Goals |
| **Unit V**<br><br>***Environmental Ethics*** | Concept of environmental ethics; Biocentrism and Ecocentrism; Application of ethics to environmental issues: Ecofeminism |
| ***Current Contour*** | Discussion of prevention control and abatement of Environmental pollution, Brain storming on natural resources conservation and the Judicial response towards Environmental Protection |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | S | S | S | S | S | S | S |
| **CO2** | S | S | M | S | M | M | S | S | S | S |
| **CO3** | S | S | M | M | M | S | S | S | M | S |
| **CO4** | S | S | S | M | S | S | S | S | M | M |
| **CO5** | S | S | S | S | S | S | S | S | S | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Environmental law Bell, S.,Mc Gillivray, D.,Pedersen, O.,Lees,E., & Stokes, E.(2017), Oxford University
2. Environmental Compliance Handbook, Jacob I. Bregman, Robert D. Edell, (2016), Lewis Publications
3. Environmental law, policy, and economics: Reclaiming the environmental agenda, (2008), Ashford, Nicholas Askounes, and Charles C. Caldart. Mit Press.
4. Environmental Laws: Summaries of Major Statutes Administered by the Environmental Protection Agency(EPA) Fletcher,S.R.(Ed.),(2008)..Nova Publishers.
5. Environmental law in India Leelakrishnan,P.(2016)..LexisNexis.
6. India's Environmental Policies, Programmes and Stewardship, Dwivedi, O.P. (2016). Springer.
7. Environmental Law from the Policy Perspective: understanding how legal frameworks influence environmental problem solving, Mc Guire,C.J.(2014). Routledge.


## Related Online Contents:

- https://www.coursera.org/learn/environmental-law
- https://www.esf.edu
- https://indianlegalsolution.com
- https://www.mondaq.com
- http://www.envis.harayana.gov.in

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# SEMESTER - I

**Laboratory Course –I - ENVIRONMENTAL CHEMISTRY & ENVIRONMENTAL MICROBIOLOGY**

| Course Code | LC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5 | 3 | | |
| Pre-requisite | Practical knowledge of basics of Chemistry and Microbiology | | | | | | | | |

## Course Objectives:

- *The course will make the students familiar about the isolating, identifying and culturing the microorganisms facilitating their usage for various other studies.*
- *The learner will be exposed to various molecular identification protocols.*

## Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The students are introduced to the diversity of microbial populations in the Environment | **K1** |
| CO2 | The practical provides knowledge to the students to learn the role of microbes in the environmental processes | **K2,K3** |
| CO3 | The role of microbial activities in sustaining the natural ecosystem and environmental quality is also understood from the practical | **K4** |
| CO4 | Techniques for characterizing microorganisms and investigating microbial processes is also provided | **K4** |
| CO5 | The students will understand the basic concepts of standardization and about the preparation of standard solutions. They will know about the principles of conductometry, volumetry and colorimetry. They would be in a position to prepare heavy metal solutions and could construct a standard graph for the same | **K6** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

1. Introduction to General Microbiology: Laboratory Rules, Microscopy, Sterilization, Preparation of Culture Media, Isolation of Bacteria from Soil, Isolation of fungi from Soil, Ubiquitous nature of Microorganisms.
2. Types of staining techniques: Simple staining, Gram staining, Capsular staining and Endospore staining.
3. Demonstration of motility for bacteria by hanging drop technique
4. List of Biochemical Test: Indole production, Methyl Red, Voges Proskaeur, Citrate Utilization, Triple Sugar-Iron agar, Catalase and Oxidase Test
5. Antibiotic sensitivity test: Disc diffusion method 6. Enzymatic test of Milk by Methylene blue reductase.
7. Most Probable Number (MPN): Presumptive, Confirmatory and complete test
8. Identification of Fungi: Lacto phenol cotton blue test
9. Molecular identification of unknown bacteria: Isolation of genomic DNA, PCR amplification of 16S rRNA and Phylogenetic analysis of 16S r RNA.
10. Molecular identification of unknown fungi: Isolation of genomic DNA, PCR amplification of 18S rRNA and Phylogenetic analysis of 18S r RNA.

1. Preparation of Normal Solutions (0.1N NaOH solution), Molar Solutions (0.1M EDTA solution), Primary Standard Solutions (0.1N oxalic acid solution) and Secondary Standard Solutions (0.1 N Hcl)
2. Titrimetric Analysis:
   (i) Conductometric titration:
      a) Strongacid Vs Strong base–HCl Vs NaOH
      b) Weakacid Vs Strong Base–$CH_3COOH$ Vs NaOH
   (ii) Complexometric titration:
      a) Standardization of EDTA solution
      b) Estimation of total hardness
   (iii) Volumetric titration:
      a) Standardization of Sodium thio sulphate solution
      b) Estimation of Dissolved Oxygen
3. Determination of heavy metal by colorimetric method
   a) Development of standard solution and preparation of standard graph:

      (i) Cr6+ (ii)Fe3+

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | M | S | S | S | S |
| **CO2** | S | M | S | S | S | M | S | S | S | S |
| **CO3** | S | M | S | S | S | M | S | S | S | S |
| **CO4** | S | M | S | S | S | M | S | S | S | S |
| **CO5** | S | M | S | S | S | M | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Recommended References:**

1.Environmental Microbiology: A Laboratory Manual, Ian L. Pepper, Charles P. Gerba (2004) Academic Press.

2.A Manual of Environmental Microbiology-Fourth edition, Cindy H.Naatsu, Robert V.Miller and Suresh D.Pillai (2016) Yates Publisher,ASM Press.

3.A Laboratory Manual for Environmental Chemistry, R. Gopalan, R. Wilgred Sugumar (2013), I.K.International Pvt.Ltd

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## SEMESTER – I

**Value Added Course 1: ECO-FRIENDLY PRODUCTS**

| Course Code | VAC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2 | 1 | - | 2 | | |
| Pre-requisite | Idea on Environmental Conservation | | | | | | | | |

**Course Objectives:**

- *To understand the importance of reducing waste and to know about the ways to create less toxic waste.*
- *To design and develop eco-friendly products and processes towards accomplishment of the sustainable development goals.*

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The students becomes aware of the ill effects of plastics and advantages of plastic of biological origin | **K5,K6** |
| CO2 | The learner acquires knowledge regarding the biofertilizers in terms of production, advantages | **K1,K2** |
| CO3 | The student would highlight the importance of biopesticides | **K5.K6** |
| CO4 | One would know about the possibility of reusing the certain household products | **K2,K3,K4** |
| CO5 | The student is exposed to 3R concept. The learner would know the possible alternatives ensuring sustainability. | **K2,K3,K6** |
| **K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation** | | |

| | |
|---|---|
| **Unit I**<br><br>***Bioplastics*** | Definition of bioplastics, Types of bioplastics, genetically modified bioplastics. Environmental impact of Bioplastics and their biodegradation, Applications and manufacture of Bio Plastics |

| | |
|---|---|
| **UNIT II**<br>***Bio fertilizers*** | Introduction and types and importance of biofertilizers, History of biofertilizers production, Classification of bio fertilizers, microorganisms used in bio fertilizers production, Quality standard for bio fertilizers. |
| **Unit III**<br>***Biopesticides*** | Introduction and types and importance of Bio pesticides and bioagents in agriculture and organic farming System, Different methods of application of biopesticides and bioagents, Strategies of marking and Registration with CIB of bioagents and biopesticides, Quality parameters as per CIB specifications. |
| **Unit IV**<br>***Reusable products*** | House hold items in daily use, Day today use of organic products in domestic use. List of organic products, effects of chemical products on environment and human**.** |
| **Unit V**<br>***Sustainability of the environment*** | Stages in Product Life Cycle, Eco-efficiency and the importance of the 3Rs, Transitioning to more resource efficient economy, Conventional waste management and its consequences. |
| ***Current Contour*** | Improved Biomass Energy Technologies – Benefits and Challenges – The Kenya Ceramic Jiko – Smokeless chulhas – Bagasse-based co-generation |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | M | M | M | S | S | S |
| **CO2** | M | M | S | S | S | S | M | M | M | S |
| **CO3** | S | S | S | M | M | M | S | S | S | S |
| **CO4** | S | S | M | M | M | S | S | S | M | S |
| **CO5** | M | M | S | S | S | S | M | M | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Introduction to Soil Microbiology. Alexander M. (1977), John Wiley.
2. Methods for Evaluating Biological Nitrogen Fixation Bergerson FJ. (1980). John Wiley and Sons.
3. Biofertilizer Technology, Marketing and Usage- A Source Book-cum-glossary Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. (1995). FDCO, New Delhi.
4. Biofertilizers in Agriculture and Forestry. Subba Rao, N.S. (1993). Oxford and IBH. Publ. Co., New Delhi.
5. Formulation of Microbial Biopesticides, Burges, H.D. (1998), Springer Dordrecht
6. Biological Control of Insect Pests, Saxena, A.B. (2003). Anmol Publ. New Delhi.

8. Theory and Practice of Biological control. Huffaker, C.B. and Messenger, P.S. (1976). Academic Press, New York.


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## SEMESTER - II

**CORE IV: WATER, SOIL POLLUTION AND MANAGEMENT**

| Course Code | CC04 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 1 | | 5 | | |
| Pre-requisite | Basic knowledge regarding pollutants | | | | | | | | |

### Course Objectives:

- *This course helps to identify the sources, effects of water and soil pollution and the methods to be employed for the control of the same*
- *The course also describes the water quality standards and the laws and rules available for the water quality management. Further the course also includes the causes, effects of soil pollution along with the control methods available for the same*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The learner would understand about the physico chemical and biological characteristics of the water and wastewater | **K1,K4** |
| CO2 | The importance of watershed management is clearly explained | **K2** |
| CO3 | The learner could think about the uniqueness of water and the need for its conservation is made to be understood | **K2,K7** |
| CO4 | The treatment techniques available for drinking and wastewater is made clear. Hence, the learner could plan a research work based on the syllabus for the betterment of the water quality | **K2,K3** |
| CO5 | The student could get employed in waste water treatment plants, industries, STP's, Pollution control boards or could promote domestic or industrial waste water treatment by himself/herself | **K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Sources of Water and Pollution*** | Distribution, Hydrological Cycle, Structure and Polarity of Water Molecule, Properties of Water – Surface Tension, Specific Gravity, Cohesion and Adhesion, Boiling Point, Freezing Point, Density, Water Sources – Availability & Quality of Surface Water (River, Stream Lake, Dam) & Ground Water (Open Well & Bore Well)- Sources of Pollution - Point and Non-Point- Types and Effects of Water Pollutants - Organic Pollutants, Pathogens, Nutrients and Agriculture Runoff, Suspended Solids and Sediments (Organic and Inorganic), Inorganic Pollutants (Salts and Metals), Thermal Pollution, Marine Pollution and Radioactive Pollution- Sources and Effects- Water Borne Diseases--causative agents and effects, Cultural Eutrophication, Asphyxiation. |
| **Unit II**<br><br>***Wastewaters and their Characteristics*** | Sampling – Grab and Composite. Physico-chemical Characteristics of Water and Wastewater – Temperature, Colour, Taste and Odor, pH, EC, TS (TSS and TDS), Turbidity, Acidity, Alkalinity, Total Hardness, Cations, Anions, Metals and Non Metals (CO3, HCO3, Cl, SO4, B, N-NO3, Ca, Mg, Na, K, RSC, PO4, Zn, Cu, Mg, Fe, Cd), MLSS, DO, COD, BOD, Microplastics, Emerging Contaminants – Pharmaceuticals, microplastics, endocrine-disrupting chemicals, and their long-term impact on ecosystems-Characteristics of Domestic Sewage and Industrial Effluents with Reference to Paper, Electroplating, Pharmaceutical, Dairy, Distillery, Dyeing, Nuclear, Fertilizer Industries. |
| **Unit III**<br><br>***Control of Water Pollution*** | Primary Treatment – Equalization, Coarse Solids Reduction (Comminutors, Macerators and Grinders), Grit Removal, Grease Removal and Skimming, Flocculation, Sedimentation, Clarification, Flotation, Aeration – Conventional Biological or Secondary Treatment – Septic and Imhoff Tanks, Trickling Filters, Rotatory Biological Contractors (RBC), Activated Sludge Process (ASP), Stabilization Ponds, Aerated Lagoons, Anaerobic Treatment and Disinfection (Chlorine, UV, H2O2, and Ozone) – Tertiary or Advanced Treatment – Adsorption, Ion Exchange, N Removal (Air Stripping, Biological Nitrification and Denitrification), P Removal, Membrane Process – Microfiltration, Ultrafiltration, Nano Filtration, Reverse Osmosis – Sludge Stabilization and Disposal – Limitations of Reverse Osmosis |
| **Unit IV**<br>***Management of Water Pollution*** | Specifications for Drinking Water (Physical, Chemical & Bacteriological) by Bureau of Indian Standards, USEPA& World Health Organization - Acts (The Water (Pollution And Control Of Pollution) Act, 1974 and The Environmental (Protection) Act, 1986), Water (Prevention & Control of Pollution) Cess Act, Rules and Regulations- Water (Prevention & Control of Pollution) Rules 1974, Water (Prevention & Control of Pollution) Cess Rules 1978, Water Quality Index (WQI) – Watershed Management-Types, Objectives and Factors Affecting Watershed Management and Management Practices (Vegetative and Engineering Measures) - Water foot print-Blue, Green and Grey- Case Studies – Minamata Disease, Itai-Itai, Fukushima Daiichi Nuclear Disaster, Indonesian Red River. |

| | |
|---|---|
| **Unit V**<br><br>***Soil Pollution*** | Soil Formation Processes: Weathering, parent material, and climate influences on soil development-Soil Horizons: Description of the different layers in soil profiles (O, A, E, B, C, R horizons)-Soil Fauna and Flora: Role of microorganisms, earthworms, and other soil organisms in soil health - Characteristics of Soil – Structure, Texture, Colour, Porosity, pH, EC, Organic Matter, Micro and Macro Nutrients, Cation Exchange Capacity, Physical Properties – Bulk Density, Porosity, Soil Water, Soil Temperature, Soil Acidity, Salinity - Main Sources of Soil Pollution– Main Types of Soil Pollutants – Organic and Inorganic Contaminants (Pesticides and Heavy Metals) – Methods for Soil Remediation *in situ* Decontamination, *ex situ* Decontamination: On-Site and Off-Site; and Confinement/Isolation of The Affected Area. |

| | |
|---|---|
| ***Current Contour*** | Treatment of different industrial waste water distilleries, tanneries, dyeing industries. Nano adsorption. Zero waste, Green technologies removal of suspended soil – micro straining. Removal of dissolved solids, Ro, removal of nitrogen. Removal of dissolved organic compounds, adsorption. Water auditing, wastewater irrigation, biochar for wastewater treatment. Interdependence between water and energy, water use in power generation, and energy use in water treatment. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | S | L | M | S | S | S |
| **CO2** | S | S | M | M | M | L | S | M | M | M |
| **CO3** | S | S | S | S | M | M | S | S | S | M |
| **CO4** | L | M | L | S | M | M | M | S | M | M |
| **CO5** | S | S | M | M | S | L | M | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Recommended References:**


1. Biological process design for wastewater treatment, Benefield, L.D. and C.W. Randall, (1980), Published by Englewood Cliffs:Prentice Hall.
2. Chemistry for Environmental Engineering, Sawyer CN, Mc Carty PL and Perkinn GF, (1994), II edition. McGraw Hill.
3. Elements of Environmental Engineering, Duggal KN (1998), Chand and company Ltd., New Delhi.
4. Environmental Chemistry, Bhatia SC,(2002),CBS Publishers andDistributors. New Delhi.
5. Environmental Chemistry, Sharma BK and Kaur H, (1994), GoelPublishing House, Meerut.
6. Spellman, F. R. (2014). Handbook of Water and Wastewater Treatment Plant Operations (3rd ed.). Boca Raton, FL: CRC Press.
7. Manahan, S. E. (2011). Water Chemistry: Green Science and Technology of Nature's Most Renewable Resource (2nd ed.). Boca Raton, FL: CRC Press.
8. Drechsel, P., Scott, C. A., Raschid-Sally, L., Redwood, M., & Bahri, A. (2009). Wastewater

Irrigation and Health: Assessing and Mitigating Risk in Low-Income Countries. London, UK: Earthscan.
9. Viessman, W., & Hammer, M. J. (2009). Water Supply and Pollution Control (8th ed.). Boston, MA: Pearson.
10. Gray, N. F. (2017). Water Technology: An Introduction for Environmental Scientists and Engineers (4th ed.). New York, NY: Elsevier.
11. Alloway, B. J. (Ed.). (2013). Heavy Metals in Soils: Trace Metals and Metalloids in Soils and their Bioavailability (3rd ed.). Dordrecht, Netherlands: Springer.
12. Sparks, D. L. (2003). Environmental Soil Chemistry (2nd ed.). San Diego, CA: Academic Press.
13. Hillel, D. (2007). Soil in the Environment: Crucible of Terrestrial Life. Amsterdam, Netherlands: Elsevier.
14. Adriano, D. C. (2001). Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability, and Risks of Metals (2nd ed.). New York, NY: Springer.
15. Sharma, B. K. (2014). Environmental Chemistry. Meerut, India: Krishna Prakashan Media.
16. Alloway, B. J., & Ayres, D. C. (1997). Chemical Principles of Environmental Pollution (2nd ed.). Dordrecht, Netherlands: Springer.
17. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). Environmental Engineering. New York, NY: McGraw-Hill.
18. Vesilind, P. A., Morgan, S. M., & Heine, L. G. (2010). Introduction to Environmental Engineering. Boston, MA: Cengage Learning.
19. Davis, M. L., & Cornwell, D. A. (2013). Introduction to Environmental Engineering (5th ed.). New York, NY: McGraw-Hill.
20. Cunningham, W. P., & Cunningham, M. A. (2019). Principles of Environmental Science: Inquiry and Applications (9th ed.). New York, NY: McGraw-Hill Education.

E-Books

1. Spellman, F. R. (2014). Handbook of Water and Wastewater Treatment Plant Operations (3rd ed.). Boca Raton, FL: CRC Press. https://www.taylorfrancis.com/
2. Manahan, S. E. (2011). Water Chemistry: Green Science and Technology of Nature's Most Renewable Resource (2nd ed.). Boca Raton, FL: CRC Press. https://www.crcpress.com/
3. Drechsel, P., Scott, C. A., Raschid-Sally, L., Redwood, M., & Bahri, A. (2009). Wastewater Irrigation and Health: Assessing and Mitigating Risk in Low-Income Countries. London, UK: Earthscan. https://books.google.com/
4. Alloway, B. J. (Ed.). (2013). Heavy Metals in Soils: Trace Metals and Metalloids in Soils and their Bioavailability (3rd ed.). Dordrecht, Netherlands: Springer. https://link.springer.com/
5. Hillel, D. (2007). Soil in the Environment: Crucible of Terrestrial Life. Amsterdam, Netherlands: Elsevier. https://www.sciencedirect.com/
6. Sparks, D. L. (2003). Environmental Soil Chemistry (2nd ed.). San Diego, CA: Academic Press. https://www.sciencedirect.com/
7. Vesilind, P. A., Morgan, S. M., & Heine, L. G. (2010). Introduction to Environmental Engineering. Boston, MA: Cengage Learning. https://www.cengage.com/oks

**Related Online Contents:**

- https://www.crcpress.com/Soil-and-Water-Contamination-

2ndEdition/Perk/p/book/9780415893435

- https://www.ebooks.com/1683186/water-pollution-xii/brebbia-c-a/
- https://www.ebooks.com/238584/water-quality-hazards-and-dispersion-of-pollutants/czernuszenko-wlodzimierz-rowinski- pawel/
- https://www.epa.gov/
- https://www.isric.org/
- https://www.fao.org/soils-portal/
- https://www.niehs.nih.gov/
- https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health

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## SEMESTER - II

**Core V: AIR POLLUTION AND ITS MANAGEMENT**

| Course Code | CC05 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Knowledge regarding atmospheric pollutants | | | | | | | | |

### Course Objectives:

- *This course is designed to present a complete understanding of the causes and effects of air pollution, the management measures and engineering technologies existing for its control*
- *Further this course also describes the noise pollution and its impact on the environment and case studies related to air pollution episodes have been elaborated.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Introduces the concept of sources of air pollutants in a clearmanner. Introduces the fate of air pollutants in a detailed manner | **K1,K4** |
| CO2 | Explains the air sampling methods and their analysis techniques | **K1,K2** |
| CO3 | An overview of different air quality standards is explained | **K1** |
| CO4 | The treatment techniques available for the air quality is explained. Various advanced treatment techniques were made to beunderstood by the learners | **K3,K7** |
| CO5 | The rules, acts and case studies regarding noise pollution was highlighted in planned manner | **K1** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Air Pollutants and Chemical Reactions in the Atmosphere*** | Classification of Air Pollutants, Sources and Effects of Oxides of Carbon, Nitrogen, Sulphur, Halogenated Compounds, Hydrocarbons, Volatile Compounds. Ions in the Atmosphere. Metereological parameters-wind speed, wind direction, temperature, humidity- Photochemical Processes – Oxidation Process, Acid - Base Reactions, Photochemical Smog, Smog Forming Reactions, Acid Rain. Fate of Atmospheric NOx, SO2, COX and O3. |
| **Unit II**<br><br>***Sampling and Analysis of Air Pollutants*** | Sampling, Classification of Sampling Methods, Difficulties Encountered, Basic Considerations of Sampling. Instruments for Sampling (Meters, Probes and Suction Devices), General Devices, Gases and Vapours – Absorbers, Adsorbers, Condensers, Collectors, Plastic Containers, Samplers for Mass Spectrometric Analysis, Duration & Location of Sampling, Methods – Sedimentation, Filtration, Impingement, Electrostatic Precipitators, Thermal Precipitation, Centrifugal Methods, Solution Impingers. Sampling for Suspended Particulates - High Volume Sampler, Stack Sampling Techniques. Analysis – Chemical, Gravimetric, Volumetric, Colorimetric, Turbimetric, Chromatographic Methods. Instrumental Methods – Emission and Absorption Spectrometry, X- ray Diffraction, Mass Spectrometry, Polarography, Radioactiviy, Microscopy, Biological Methods – Effects on Plants and Animals, Sensory Tests. |
| **Unit III**<br><br>***Air Quality Standards & Control of Air Pollution*** | Air Quality Standards, Air Quality Index, Indoor Air Quality, Control Methods Absorption, Adsorption, Condensation, Chemical Reactions, Incinerations. Devices – Wet Scrubber, Packed Towers, Plate Columns, Spray Towers, Dry Scrubbers, Gravity Separators, Baffle Chamber and Duster Louvers, Cyclone, Electrostatic Precipitators, Venture Scrubber, Fabric Bag Filters, Control in Disposal. The Air Act of 1981, MoEF&CC Regulations. |
| **Unit IV**<br><br>***Noise Pollution and Control*** | Definition of Sound and Noise, Ambient Noise Levels, Sources, Types and Classification and effects of Noise. Prevention and Control – Insulation, Isolation, Volume Reduction, NIC (Noise Isolation Class) & NR (Noise Reduction). The Noise Pollution (Regulation and Control) Rules, 2000. Odour – Sources, Classification and Control Measures. |
| **Unit V**<br><br>***Case Studies*** | Notable Air Pollution Episodes – Meuse Valley – Belgium, Donora- Pennsylvania, Poza Fuca- Mexico, Flixborough Disaster – UK, Bhopal Tragedy – India, Schweizerhalle – Switzerland, London Smog, England, New York – Disasters. Air Pollution in Indian Cities – National Scenario – New Delhi, Hyderabad, Bangalore, Chennai |

| | |
|---|---|
| *Current Contour* | Fundamental Theories and Application of Air Quality Meteorology and Modeling - Air Dispersion Modeling: Gaussian and Non-Gaussian Dispersion Model (Theory, Applications), Puff Dispersion Model (Theory, Applications), Three-Dimensional Eulerian Grid Modeling - Meteorological Component - Photochemical Component - Application and Analysis. Softwares - Hysplit model, CAMx, DISPER |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | M | M | M | M | M | M | M |
| **CO2** | S | S | S | S | M | M | M | M | M | M |
| **CO3** | S | S | M | M | S | M | M | M | S | S |
| **CO4** | S | S | M | M | S | S | M | S | S | S |
| **CO5** | S | S | M | S | S | S | S | S | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Air Pollution, M. N. Rao and H.V.N. Rao, (2014), McGrawHill Education
2. Advanced Air and Noise Pollution control, Lawrence K. Wang, Norman C. Pereira, Yung-Tse Hung, (2005), Humana press.
3. Pollution Management (I Air Pollution), S.K. Agarwal, (2002), A.P.H Publishing Corporation.
4. Environmental Science and Technology, Stanley E. Manahan,(1997), Lewis Publishers.
5. Fundamentals of Air Pollution, Richard W. Boubel, Donald L. Fox, D. Bruce, Turner and Arthur C. Stern, (2005), Academicpress.

## Related Online Contents:

- https://www.youtube.com/watch?v=Mpcil0H5Pos
- https://video.nationalgeographic.com/video/101-video-shorts/ what-is-acid-rain
- http://www.science.uwaterloo.ca/~cchieh/cact/applychem/ atmosphere.html
- https://ocw.ehu.eus/pluginfile.php/12278/mod_resource/content/1/03_Lecture_notes_Air_pollution_technologies_Lesson_03_OCW2016.pdf
- www.epa.gov
- http://files.harc.edu/Sites/TERC/About/Events/Other200503/ Meteorology And Air Quality pdf

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## SEMESTER - II

**CORE VI: ENVIRONMENTAL TOXICOLOGY**

| Course Code | CC06 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Fundamentals of environmental pollutants and its toxic effects | | | | | | | | |

### Course Objectives:

- *This study provides organizational knowledge, capability and research skills in the field of toxicology and how they can apply it in developing areas concerned with health and environment*
- *This course gives understanding of uptake and distribution of environmental pollutants that affects at molecular, gene, cellular and at systemic level.*
- *Students will learn to analyze the toxicant, interpret the data and will be able to compile a scientific report to implement policies related to environmental issues*

### Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | realize the core concepts of the science of toxicology, including classification of toxicants, and route of entry of toxicants, hazard identification etc | **K1** |
| CO2 | gain knowledge and skills regarding risk assessment and to know about environmental monitoring and toxicant identification | **K1 & K2** |
| CO3 | explore the mode of action of toxicants in different organ systems with their effect causing health issues such as cancer, reproductive toxicity etc | **K3** |
| CO4 | The learners will be trained to bioassay for evaluation of toxicity using different model systems | **K4 , K5** |
| CO5 | elucidate the molecular mechanism of action in progression of diseases by toxicants through gene expression | **K5, K6, K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Introduction to Toxicology and Toxicants*** | Definition of Toxicology, Toxicity and Toxicants. Classification of toxic agents in environment: natural toxins (Phytotoxins, animal and microbial toxins) Anthropogenic toxicants. Classes of environmental toxicants; Inorganic ions (Metals-Hg, Anions-$NO_3$). Organic contaminants (DDT, Parathion and PAHs). Ionizing radiations, Detergents, Pharmaceuticals and Personal Care Products, Microplastics. |
| **Unit II**<br><br>***Entry, Distribution and Mode of Action*** | Routes of Entry – Inhalation, Absorption, Ingestion, Injection. Bio-distribution, Bio-accumulation. Bio-magnification and Biotransformation and excretion of toxic agents. Types of Toxicity – Acute, Sub-acute and Chronic effects of Toxicants. Dose-Response Relationship – LC50, LD50, EC50, Short Term and Long term. Mode of Action: Reactions of Toxicants with Target Molecules –Covalent Binding, Non-covalent Binding, Hydrogen Abstraction, Electron Transfer and Enzymatic Reactions |
| **Unit III**<br><br>***Systemic Toxicology*** | Toxic response of different body system - Toxicants and their effects Dermal, Respiratory, Liver, Kidney, Reproductive Organs. Endocrine disrupting chemicals, Mutagens, Teratogens, Carcinogens, hallucinogen and obesenogens |
| **Unit IV**<br>***Toxicogenomics and Proteomics*** | Introduction to toxicogenomics. Properties of nucleic acids (DNA & RNA) and its functions, Basic of eukaryote genome and chromosome organization, Central dogma (Basic concept on Replication /transcription /translation) Modification of DNA, RNA and Protein Metabolism by Toxicants. |
| **Unit V**<br><br>***Protein Synthesis and Processing*** | Concept of bioassay. Toxicity evaluation using various tests for genomic (comet assay), plants (seed germination, growth of plemule and radical), aquatic animals (Drosophila, zebra fish and rodent model). Permissible Exposure Limits (PELS). OSHA. Risk Assessment, Elements of Risk Assessment – Categories of Risk Assessment – Retroactive and Predictive, Risk Assessor, Risk Manager, Hazard Index, NAS Paradigm and its Components. |
| ***Current Contour*** | Case studies with respect to the toxicants released from Tannery, Fertilizer, Electroplating, Cement and other relevant Industries. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | L | S | S | L | S | S | S | M | M |
| **CO2** | S | L | S | L | S | S | M | M | M | M |
| **CO3** | S | M | M | M | L | M | M | M | L | S |
| **CO4** | S | M | L | M | S | S | M | L | L | M |
| **CO5** | S | S | L | L | L | M | S | L | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Essentials of Toxicology, Casarett and Doull's . Second Edn.(2010). Curtis Klaassen and John B.Watkins III. Mc Graw Hill.
2. Environmental Risk Assessment Report, Benjamin, S.L., and Bellurk,D.A.,(2001).
3. Environmental Toxicology – Biological and Health Effects of Pollutants, Ming-Ho Yu, (2004), Second Edition, CRC Press (Taylor &Francis Group).
4. Environmental Toxicology-Engineering Tools for Environmental Risk Management, Katalin Gruiz, Tams Meggyes and Eva Fenyvesi,(2014),CRCPress (Taylor & FrancisGroup).
5. Essentials of Toxicology – KlassenCD,Watkn J.B(2003) 3 rd Ed., Mc Grew Hill, NewYork
6. Fundamentals of Ecotoxicology, MichaelC. Newman, (2001), Lewis Publishers.
7. Handbook of Ecotoxicology, David J. Hojjman, Barnett A. Rattner, G. Allen Burton, Jr., and John Cairns,Jr.,( 2000),CRCPress (Taylor & Francis Group).
8. Information Resources inToxicology:Wexler,Philipet al,2000.3rd ed. Academic press, 2000.
9. Introduction to EnvironmentalToxicology-Wayne. G.Landis,MingHo Yu, 3rd Ed. (2002) Lewis Publishers, CRCpress, NY.
10. LU's Basic Toxicology (Fundamentals, Target Organs and Risk Assessment), Sixth Edition, Samkacew and Byung-Mu Lee, (2013), CRCPress (Taylor & Francis Group).


## Related Online Contents:

- https://envirotoxinfo.nlm.nih.gov/
- https://ctdbase.org/
- https://www.evotec.com/en/panomics/toxicogenomics
- https://19january2017snapshot.epa.gov/chemical-research/computational-toxicology-communities-practice_.html
- https://onlinelibrary.wiley.com/page/journal/15227278/homepage/video-gallery

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## SEMESTER - II

**CORE OPTIONAL 1: ENVIRONMENTAL ANALYTICAL METHODS**

| Course Code | CO02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Basic Principle of instrumental analysis | | | | | | | | |

### Course Objectives:

- *Environmental analysis and monitoring is a very demanding and dynamic field, and this course involves instrumental qualitative and quantitative determination of contaminants / chemicals from ppm to very trace levels, and the ever changing requirements for regulatory compliance in monitoring drinking water, wastewater, ambient/emission air, and solid/hazardous wastes.*

### Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand about the principle of various types of microscopy | K1,K2 |
| CO2 | Gain knowledge regarding the separation techniques used for analytical studies | K2 |
| CO3 | Know about the principle and mechanism of various sophistical instruments | K3,K4 |
| CO4 | Acquire information regarding the techniques important to molecular biology and genomics | K5 |
| CO5 | Discuss the methods used to study protein expression, detect DNA sequences the biological samples. Develop knowledge regarding selection of methods needed for their analysis | K6,K7 |
| K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation | | |

| | |
|---|---|
| **UNIT I**<br>***Microscopy*** | Introduction to Microscopy, Fixation and Staining. Principles and applications of Light, Phase Contrast, Fluorescence, Confocal, Atomic Force, Scanning Electron and Transmission Electron Microscopy (SEM & TEM), Cytophotometry. |

| | |
|---|---|
| **UNIT II**<br>***Separation Techniques*** | Centrifugation – Differential and Ultracentrifugation. Principles and applications of Gel Filtration, Column, Ion-Exchange, Size Exclusion and Affinity Chromatography. Paper chromatography, TLC, HPLC, GC. |
| **UNIT III**<br>***Analytical Techniques-1*** | Titrimetry, Gravimetry, Colourimetry, Turbidimetry, Nephelometry, Flame Photometry, Elemental Analyzer, TOC Analyzer. Spectrophotometers – Fluorescence, UV-Visible and IR. NMR Spectroscopy, AAS, ICP-OES, ICP-MS, Amino Acid analyzer, GC-MS, LC-MS, Tandem Mass spectrometers, SELDI-TOF-MS, MALDI-TOF-MS and Bio-Sensors. |
| **UNIT IV**<br>***Analytical Techniques-2*** | AAS, ICPOES, ICPMS, GC-MS, LC-MS, SELDI-TOF-MS, MALDI-TOF-MS and Bio-Sensors. Principle and Application of Radioactive Isotopes, Autoradiography, Scintillation Counter, Geiger Muller Counter. |
| **UNIT V**<br>***Molecular Techniques*** | Electrophoresis- PAGE, PFGE, SDS-PAGE, Agarose Gel, Immunoelectrophoresis, 2D Electrophoresis and Gel Documentation, Principle and Application of PCR, RT-PCR, RFLP, RAPD, AFLP and DNA Fingerprinting. |
| ***Current Contour*** | X-ray Absorption Fine Structure (EXAFS) and X-ray Absorption Near Edge Structure (XANES), SEM - Back-scattered and secondary electron imaging, Electron Microprobe Analysis (EMA) |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | M | M | S |
| **CO2** | S | S | M | S | S | S | S | S | M | S |
| **CO3** | S | S | M | M | S | M | S | S | M | S |
| **CO4** | S | S | M | M | S | S | S | S | M | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Recommended References:**


1. Biochemistry Laboratory: Modern Theory & Techniques, Rodney F. Boyer (2006), Prentice Hall.
2. Biophysical Chemistry: Principles & Techniques, Avinash Upadhyay, Kakoli Upadhyay, Nirmalendu Nath (2009), Himalaya Publishing House
3. Biosensors, Jon Cooper, Tony Cass (2004), Oxford University Press, USA
4. Biotechniques of Ecology, Ashok Kumar (2006), Discovery Publishing Pvt.Ltd, New Delhi
5. Fundamental Concepts in Biophysics, Thomas Jue (2009), Humana Press
6. Mass Spectrometry for Biotechnology, Gary Siuzdak (2006), Elsevier New Delhi Academic Press

7. Mass Spectrometry of Proteins & Peptides, Lipton Mary S, Paša- TolicLjiljana (2009), Humana Press
8. Principle & Techniques of Biochemistry & Molecular Biology, Keith Wilson, John Walker (2010), Cambridge University Press.

## Related Online Contents:

- http://nptel.ac.in/courses/102103044/pdf/mod2.pdf
- Analytical Chemistry https://kanalispolban.files.wordpress.com/2012/04/analytical_chemistry.pdf
- https://www.pdfdrive.com/download.pdf?id=912659&h=c1beb8cca20136a30c73f39f19c8dd81&u=cache&ext=pdf
- Principles and Practice of Analytical Chemistry http://sci-lib.org/books_1/F/fifield.pdf

## WEB LINKS

- https://www.epa.gov/pesticide-analytical-methods/ environmental-chemistry-methods-ecmindex
- https://www.microscopyu.com/microscopy-basics
- http://elte.prompt.hu/sites/default/files/tananyagok/ Introduction To Practical Biochemistry/ch06.html
- http://nptel.ac.in/courses/102103013/module3/lec4/2.html

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# SEMESTER - II

## CORE OPTIONAL 2: INDUSTRIAL HEALTH AND SAFETY MANAGEMENT

| Course Code | CO02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Idea regarding Industrial Processes | | | | | | | | |

### Course Objectives:

- *To impart knowledge on various occupational health hazards and educate the students about the safety measures to be taken in the work place.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOME | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The students will be able to understand the various possible hazards in a working environment | **K1,K2** |
| CO2 | The student will be able to employ safety devices for mitigation of hazards | **K3** |
| CO3 | The student will be aware of environmental safety standards and certification | **K4** |
| CO4 | The learner would know about safety auditing and management systems | **K5** |
| CO5 | The learner will be aware of the accidents and the strategy to be used for its prevention. The students could know the legislation available for the same | **K2** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **UNIT - I**<br><br>***Occupational Health*** | WHO concepts of environmental health, Hazards and Safety – Physical, Chemical and Biological hazards. Occupational Diseases and Occupationally induced illness - Prevention and Control. Health problems in different types of industries – construction, textile, steel and food processing, pharmaceutical, Occupational Health and Safety considerations in Wastewater Treatment Plants. Measures for Workers. Health Education Medical First-Aid and Management of Medical Emergencies. Epidemiological approaches. Ergonomics – Need, Task Analysis, Preventing Ergonomic Hazards, Ergonomics Programme. Definition and Role of Ergonomics in Designing Work Place - Work Environment - Effects of Light, Ventilation, Vibration, Noise and stress - Performance Evaluation of Man. |

| | |
|---|---|
| **UNIT – II**<br><br>***Industrial Safety Management Techniques*** | Industrial Safety Standards. Industrial Accidents and Disasters - Frequency Rate, Prevention and Control. Dispersion of Radioactive material and release of Toxic and inflammable materials. Work Study Method of Study and Measurement. Measurement of Skills. Safety Cost of Expenses. Principles and Functions in Safety Management. Case Study - Preparation of report on safety and remedial measures followed in Industry. |
| **UNIT- III**<br><br>***Hazards Exposure evaluation*** | Sampling techniques, Personal monitoring, Biological monitoring; Threshold Limit Values (TLV), STEL; List of Industries involving Hazardous Process Occupational Hazards under the First Schedule of the Factories Act,1948; Permissible Limits of certain Chemical substances in work environment under the Second Schedule of the Factories Act,1948; Hazards Control: Elimination, Control, Substitution, Isolation, Personal Protective Equipment(PPE). |
| **UNIT - IV**<br><br>***Hazards Control*** | Causes of Accident - Accident statistics - Accident Reporting system, Safety Audit, Accident prevention, Disaster Planning, Safety Committee, Case studies on Bhopal, Chernobyl and similar disasters - Control of Hazards Substitutions, Engineering control, Administrative control, Behaviour control, integrated control, Elimination, Control, Substitution, Isolation, Personal Protective Equipment (PPE), Databases of hazardous chemicals. |
| **UNIT- V**<br>***Labour laws*** | Occupational Safety and Health Act and Health Administration, right to know Laws- Indian Acts – Labour Act, Factories Act, OSHA. Parameters of safety – Factors affecting the conditions of occupational and Industrial safety – Concept of safety organization and Management - Safety Regulations - Supervisors and safety departments. |
| ***Current Contour*** | Workplace safety, best practices, Costs of occupational injury – need for training – role of health and safety replacement regarding industrial safety |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | M | S | M | S | S | S | M | S | S |
| **CO3** | S | M | S | M | S | S | M | M | M | M |
| **CO4** | S | M | S | S | M | S | S | S | M | M |
| **CO5** | S | S | S | S | S | M | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Occupational Safety and Health for Technologists, Engineers and Managers, Goetsch, D.L. (1999), Prentice Hall.
2. Safety and Environmental Management, Della - Giustina, D.E. (1996), Van Nostrand Reinhold Publishing Inc. New York.
3. Environmental Strategies–Hand Book, Kolluru, R. V. (1994), McGraw Hill Inc., New York.
4. A B C of Industrial Safety, Walsh, W. and Russell, L. (1984), Pitman Publishing Ltd., United Kingdom.
5. Environmental and Industrial Safety, Hommadi, A. H. (1989), I.B.B. Publication, New Delhi.

## SEMESTER - II

**Elective A: ENVIRONMENTAL IMPACT ASSESSMENT**

| Course Code | EC02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Knowledge on basics of Environmental assessment | | | | | | | | |

### Course Objectives:

- *This course discusses the need of industry and society to predict and include environmental concerns and risks while developing different projects*
- *The course also describes the modern tools and techniques to evaluate the environmental impacts and outlines various management options needed to mitigate these risks*

### Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand the importance of EIA | **K1,K2** |
| CO2 | Learn the types and methodologies of EIA process | **K3,K5** |
| CO3 | Understand the impact of projects on air, water, biological and socio-economic environment | **K5,K7** |
| CO4 | Understand the importance of environmental ethics | **K5** |
| CO5 | Know about the national and international protocols on EIA | **K6,K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **UNIT I**<br><br>***Fundamentals of EIA*** | Definition and Evaluation of EIA in India – Types of EIA: Rapid EIA, comprehensive EIA, strategic EIA, data collection, ecological impacts, environmental impacts (Air, water, land and noise), socioeconomic and cultural impacts, health impacts, prediction of impacts – Fundamental Steps involved- Screening, Scoping and Baseline Studies, Significance and Importance of Impacts, Impact Prediction, Mitigation Aspects- Assessment of Alternatives, Public Hearing, Decision Making. |

| | |
|---|---|
| **UNIT II**<br><br>***EIA Methodologies*** | EIA Guidelines- EIA Methodologies-Checklist Methodologies – Adhoc Method – Network Methods – Matrix Methods – Map Overlay Method, Preparing EIA – Interacting Parameters – Cost-Benefit Analysis (CBA)- Public Participation Method – Comparative Studies on Methodology. Prediction and Assessment of Impacts on Biological, Surface Waters, Ground Water, Air, Noise, Radiation Hazards. |
| **UNIT III**<br><br>***Environmental Laws and Acts*** | Environmental Policies – National and International Trends, Changes in Global Perspective, International Treaties. National Policies: National Environmental Policy, National Forest Policy, National Water Policy, Rehabilitation and Resettlement Policy; Evolution of Environmental Legislations in India, Legal Provisions for Environmental Protection; Various Acts, Rules and Regulations. International Agreements; Paris Agreement, Convention on Biological Diversity; Montreal Protocol; Ramsar convention, Environmental Standards, Criteria for Standards Setting. Public Liability Insurance Act and Legal Aspects Relating to Hazardous and Toxic Substances. Role of National Green tribunals |
| **UNIT IV**<br><br>***Environmental Ethics*** | Environmental Ethics – Definition, Instrumental and Non – Instrumental value – Anthropocentric approaches– Holistic Environmental Ethics – Monism and Pluralism- Wilderness and Ecological Restoration – Environmental Justice and Sustainability- Environmental Ethics and Climate Change Environmental Pragmatism- Ethical theories- Importance and limitations of ethics, Environmental Ethics in India- Biocentrism, Ecocentrism, Ecofeminism. |
| **UNIT V**<br><br>***Case Studies*** | Land Clearing Projects – Dam Sites – EIA for Aquaculture, Steel, Mines, Hydrothermal, Nuclear, Oil and Gas based Power Plants- Highway Projects-Industrial Projects. Damage to Coral Reefs in Oceans. |
| ***Current Contour*** | Red mud disaster, Mining project's economic impact on local communities, Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity, Software tools (MFA, LCA), Workplace and indoor exposure in Risk and Life Cycle Assessment. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | S | M | S | S | M | S | M | S | S |
| **CO2** | S | M | S | M | M | M | S | M | M | S |
| **CO3** | M | S | M | M | S | M | M | S | S | M |
| **CO4** | M | M | S | M | M | M | M | M | M | M |
| **CO5** | S | S | M | S | M | S | M | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Environmental Impact Statements, Bregmam J.I (1999), Lewis Publishers, London.
2. Environmental Science and Engineering, Suresh K.Dhameja, (2005), Published by Sanjeev Kumar Kataria, Delhi.
3. Effective Environmental Assessment, Eccleston C.H, (2000), Lewis Publishers, London.
4. Textbook of Environmental Studies, EranchBharucha, (2005), University Grants Commission 5. Environmental Production, Law and Policies, Jane Holder and Maria Lee, (2007), Second Edition.
6. Introduction to Environmental Impact Assessment,Natural and Built Environment Series. John Glasson (2005), Routledge, Taylor and Francis.
7. Environmental Assessment, Singleton R, Castle P and Sort D (1999), Thomas Telford Publishing London.
8. Environmental Impact Assessment, Larry W. Canter (2013), John Wiley and Sons.
9. An overview of Environmental ethics. Clare Palmer. (2012), Lousis P. Pojman and Paul Pojman (Eds.,) Environmental Ethics – Readings in Theory and Application 6th edition. Cengage learning, Nelson Edn. ltd., Canada.
10. Introduction to Environmental Impact Assessment , John Glasson and Riki Therivel (5th ed., 2019).
11. Environmental Impact Assessment: A Journey to Sustainable Development, Rachna Bhateria, Mona Sharma, and Sumit Kumar (2024).
12. Advanced Introduction to Environmental Impact Assessment, Angus Morrison-Saunders (2021).

**EBOOKS**

- https://www.pdfdrive.com/environmental-and-social-impact-assessment-e20696281.html
- https://www.pdfdrive.com/environmental-impact-assessment-and-environmental-managementplan-eia-e41362001.html
- https://www.pdfdrive.com/environmental-impact-assessment-and-strategic-environmentalassessment-e39961330.html
- https://ebooks.inflibnet.ac.in/esp12/chapter/eia-methodology/
- www.annualreviews.org, Environmental Ethics


## Related Online Contents:

- http://www.energia.bme.hu/pub/hullgazd/Environmental %20Engineers%27%20Handbook/Ch02.pdf
- http://onlinelibrary.wiley.com/doi/10.1002/0471238961. envilawr.a01/abstract;
- http://pcbassam.org/EIAREPORT/Jumbo_Roofings-EIA.pdf

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## SEMESTER - II

**Elective B: DISASTER MANAGEMENT**

| Course Code | EC02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Basics of Natural and Manmade disasters | | | | | | | | |

### Course Objectives:

- *The course focuses on the reasons responsible for disaster, its impact on the environment and society*
- *To measures and steps to be taken to minimize or overcome the burden on the ecosystem.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand the types of natural disasters and identify the level of impacts on natural resources. | K2, K4 |
| CO2 | Evaluate the damage on human life and Understand about the disaster preparedness. | K7,K2 |
| CO3 | Develop a knowledge network on disaster management. | K6 |
| CO4 | Estimate the economic values of damages. | K7 |
| CO5 | Update the training skills towards disaster preparedness. | K1,K3 |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **UNIT I**<br>***Introduction to Disasters*** | Natural Disasters – Educative – Trends in Climatology, Meteorology and Hydrology. Seismic Activities. Changes in Coastal Zone, Coastal Erosion, Beach Protection. Coastal Erosion due to Natural and Manmade Structures. |

| | |
|---|---|
| **UNIT II**<br><br>***Types of Disasters*** | Disasters – Nature and Characteristics of Cyclones – Tornadoes – Avalanches – Flood –Drought – Volcanic – Earthquakes – Fire – Landslides – Causes and effects - Impact on Environment-Forecasting and Warning System – Disaster Profile of India. |
| **UNIT III**<br><br>***Disaster Management*** | Predisaster Planning – Toning of Disaster – Prone Areas – Prioritization – Regulations – Protection Measures during Disaster and Post Disaster. Relief Camp Organization – Survey and Assessment. Disaster Management Cycle – Vulnerability Analysis – Disaster Training – Legal Aspects – Case Studies for Disasters and Management. Technology for Disaster Management – Role of Information and Communication Technology, GPS, Remote Sensing and Geographic Information System in Disaster Management. |
| **UNIT IV**<br><br>***Disaster Preparedness and Training*** | Community Preparedness in Natural Disasters – Role of Information, Education, Communication and<br>Training – Roles and Responsibilities of Different National and International Agencies and Government – NGO, Armed Forces, Paramilitary Forces, Community Based Organizations (CBO) – Army Training for Disaster Reduction – Role of Team and Co-Ordination – Training Needs. |
| **Unit V**<br><br>***Mitigation Strategies*** | Disaster Mitigation – Emerging Trends in Disaster Management – UN Draft Resolution on Strengthening of Coordination of Humanitarian Emergency Assistance, International Decade for Natural Disaster Reduction (IDNDR), Policy for Disaster Reduction, Problems of Financing and Insurance. Training for Emergency. Regulation/Guidelines for Disaster Tolerance Building Structures. |
| ***Current Contour*** | Field visit to Tsunami affected areas – Observation visit Cyclone hit areas of near Cuddalore and Chidambaram areas – Visit to Landslide vulnerable areas at Ooty and Kodaikanal – Group discussion about Chennai Flood 2015 and Sand mining at Cauvery river basin etc. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | M | S | M | M | M | M | M | M | M |
| **CO2** | M | M | M | S | M | M | M | M | S | S |
| **CO3** | S | M | S | M | S | S | S | S | S | S |
| **CO4** | M | S | M | S | M | M | M | S | M | L |
| **CO5** | M | M | M | S | S | M | S | M | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. A Manual on Disaster Management. Dr. ParagDiwan. (2010). Pentagon Earth.
2. Disaster Management: A disaster Manager's Handbook, Carter, N W. (1992), Asian Development Bank, Manila.
3. Early warning Systems for Natural Disaster Reduction. JochenZschau, Andreas N. Kuppers. (2003). Springer-Verlag, Berlin Heidelberg.
4. Earthquake: A Natural Disaster. GautamAshutosh (1994), Ashok Publishing House. New Delhi.
5. Natural Disaster, Sharma, R.K. & Sharma, G. (2005), (ed) APH Publishing Corporation, New Delhi.
6. Natural Hazards and Disaster Management; Vulnerability and Mitigation. R.B. Singh. (2006), Rawat Publications.
7. Natural Hazards, Bryant Edwards (2005), Cambridge University Press, U.K.
8. Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Roy, P.S. (2000), Indian Institute of Remote Sensing (NRSA), Dehradun.


## Related Online Contents

- www.ndma.gov.in/en/
- www.adpc.net/
- www.isro.gov.in
- www.dmibhopal.nic.in/
- www.nasa.gov

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## SEMESTER - II

**Elective C: GLOBAL WARMING AND CLIMATE CHANGE**

| Course Code | EC02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Knowledge on Greenhouse gases and GHE | | | | | | | | |

**Course Objectives:**

- *This course introduces the main aspects of climate and how it is altered due to various anthropogenic activities*
- *. It also covers the Science of climate changes and the risks it causes*
- *The students will also learn about the potential impact on society, economy and environment due to climate change and the action plan involved in its mitigation.*

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The learner could understand the climate variables | **K1, K2** |
| CO2 | The student would obtain the knowledge about the climate change and seasonal changes | **K2** |
| CO3 | The student could learn about the factors influencing climate change | **K4, K7** |
| CO4 | One can understand about the significance of global warming on human life and agriculture | **K2, K4** |
| CO5 | The learner will obtain knowledge about the inter relation between greenhouse gases, global warming and climate change. The learner understand the importance of mitigation of air pollution | **K6, K7** |
| **K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation** | | |

| | |
|---|---|
| **UNIT I**<br>***Climatology*** | Climatology-Definition, weather and climate, Microclimate –Solar radiation, greenhouse effect, heat budget, and temperature distribution- Types - Physical, Regional and Applied, Climate Classification - Empirical and Applied. Geographical Classification- Tropical Zone, Temperate and Polar Zone. Koppen's Climate Classification. World Classification Based on Climate Profile. Climatology through Various Eras (Cenozoic, Mesozoic, Paleozoic, Precambrian) |

| | |
|---|---|
| **UNIT II**<br>***Global Warming*** | Global Temperature, Influence of Green House Gases on Global Warming- Causes of Global warming -Global warming and its impacts of Environment Intergovernmental Panel on Climate Change (IPCC), Projections for Future Climate Change. Modeling Global Climate Change - Computer Models, Accuracy of Climate Change Prediction Models, Extreme Climate Events and Vulnerability |
| **UNIT III**<br>***Climate Change*** | Definition of Climate Change – Causes and Impacts of Climate Change (Green House Gases - Sources, Effects, Extreme Weather Events. Role of Oceans and Forests as Carbon Sinks, Stratospheric Ozone Shield and Ozone depletion. Effect of Climate Change on Weather and Climatic Patterns, Melting Ice Caps, Glaciers impact an Agriculture and Biodiversity, Sea Level Rise and Tourism - Climate change modelling, Global change in temperature and climate and changes within India |
| **UNIT IV**<br>***Mitigation Strategies*** | Importance of Climate Mitigation, Strategies – Renewable Energy, Green Building, Energy Efficiency, Reducing Consumption, Low Carbon Development --Strategic Frameworks and Policy Approaches for Mitigation and Low Carbon Development. . Emission Trading and Carbon Credits. Creation of awareness, Education and conventions, COP 21: Paris climate conference (2016). |
| **UNIT V**<br>***Action Plans on Climate Change*** | National – Urban, Local Bodies, Panchayats. Climate change planning methods-International Action Plan, Policies, Protocols and Agreements. Role of UN Collaborative Programme on Reducing Emissions from Vehicles - United Nation Framework Convention on Climate Change (UNFCCC) -Key requirements of the UNFCCC, Structure, Participating Countries - Annex I, Annex II and Non-Annex I Countries. The Kyoto Protocol. Montreal Protocol. Overview of Conference of Parties (CoP). Important Climate Change Negotiations Evolved in the Past Years. Highlights of Key Issues for Future Climate Change Regime. |
| ***Current Contour*** | Group discussion on raising temperature and impact on public health. A visit to Indian Metrological Department, Chennai. Discussion on weather forecasting, Brain storming session on global warming in society |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | M | S | M | M | S | M | S | M | M |
| **CO2** | M | M | M | S | M | M | M | M | S | S |
| **CO3** | S | S | S | S | S | S | M | S | M | S |
| **CO4** | M | M | M | M | S | M | S | M | S | M |
| **CO5** | M | M | S | S | S | M | S | M | L | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Climate Change and Biodiversity: Perspectives and Mitigation Strategies - Prabha ShastriRanade, (2008), ICFAI University Press.
2. Environmental Science: Earth as a Living Planet. Botkin, Daniel B. and Keller, Edward A., (2007), 6th ed. John Wiley & Sons,USA.
3. Climate Change: A Multidisciplinary Approach. Burroughs, W.J. (2007), 2nd ed. Cambridge University Press. 2007.
4. Climate Change-An Indian Perspective. Dash, S. K. (2007), Centre for Environment Education and Cambridge University Press Pvt. Ltd., New Delhi.
5. Environmental Science: A Study of Interrelationships. Enger, E.D. and Smith, B. F. (2006),11th ed. McGraw Hill Inc., USA. 2006.
6. Climate Change: Causes, Effects, Solutions. Hardy, John T. (2003), Wiley & Sons, USA.
7. Global Environmental Issues. Harris, F. (2004), Wiley & Sons, Inc., USA.
8. One Earth one Future: -Our Changing Global Environment, Silver C. S. and De Fries, R. S. (1991), East-West Press Edition.
9. Global Environmental Challenges –Transitions to a Sustainable World. Speth, J. C. (2004), Orient Longman Pvt. Ltd., New Delhi. UNEP.
10. Climate Change: A Very Short Introduction , Mark Maslin (2023).
11. Global Warming: Understanding the Forecast by David Archer (2023).


## Related Online Contents:

- climate.nasa,gov/
- www.ucsua.org/
- www.ccsi.org/
- www.climate.gov/
- www.renewablenology.world.com
- https://www.nrdc.org/stories/global-warming-101#warming
- https://www.researchgate.net/publication/316691239_Global_Warming_Causes_Effects_and_Solutions

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## SEMESTER – II

**Laboratory Course II: Water, Soil, Air Pollution & Management, Environmental Toxicology**

| Course Code | LC02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Pre-requisite | Basics of water analysis and toxicology | | | | | | | | |

### Course Objectives:

- *This course helps the students to understand the significance of various water quality parameters to understand the quality of the water tested.*
- *The soil quality is also known by analyzing the basic parameters. Further to understand the effects toxicants on animal model and it can be used to detect in humans too.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Perform the sampling of water & test its physical, chemical characteristics | **K1,K2** |
| CO2 | Check the Microbiological quality of different water samples | **K3** |
| CO3 | Know the ambient air quality in terms of metereological parameters & Particulate matter | **K4** |
| CO4 | Understand the biochemical changes happening in rats exposed to toxicants | **K1,K5** |
| CO5 | Know about the possibility of histopathological changes due to different toxicants | **K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Experiments**<br>**Water, Soil, Air Pollution & Management** | 1. Water and Soil sampling techniques<br>2. Estimation of pH, EC in Water & Soil<br>3. Determination of Sulphate, Chloride, TS, TDS, TSS<br>4. Estimation of DO, BOD, COD<br>5. Estimation of Total Hardness, Ca, Mg in water & Soil<br>6. MPN technique<br>7. Estimation of Total organic matter, Total Organic Carbon of soil<br>8. Determination of Meteorological parameters (wind speed, wind direction, Relative humidity, Temperature)<br>9. Wind rose construction<br>10. Estimation of $PM_{10}$ in ambient air |
| **Toxicology and Toxicogenomics** | 1. Estimation of Serum Aspartate Aminotransferase (AST) in serum of rats exposed to toxicants.<br>2. Estimation of Serum Alanine Aminotransferase (ALT) in serum of rats exposed to toxicants.<br>3. Estimation of urea in serum of rats exposed to toxicants.<br>4. Estimation of uric acid in serum of rats exposed to toxicants.<br>5. Evaluation of the antioxidant enzyme Superoxide Dismutase (SOD) in liver tissues of rats exposed to toxicants.<br>6. Evaluation of lipid peroxidation (MDA) in liver tissues of rats exposed to toxicants.<br>7. Evaluation of the antioxidant enzyme Superoxide Dismutase (SOD) in kidney tissues of rats exposed to toxicants.<br>8. Evaluation of lipid peroxidation (MDA) in kidney tissues of rats exposed to toxicants.<br>9. Histopathology of liver tissue from the rats exposed to toxicants.<br>10. Histopathology of kidney tissue from the rats exposed to toxicants. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | M | S | M | S | S | S | M | S | S |
| **CO3** | S | M | S | M | S | S | M | M | M | M |
| **CO4** | S | M | S | S | M | S | S | S | M | M |
| **CO5** | S | S | S | S | S | M | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Percentage of modification = 23**

## Recommended References:


1. Standard Methods for the Examination of Water and Wastewater, American Public Health Association.24th edition, William C. Lipps , Ellen Burton Braun-Howland , Terry E. Baxter (Editors) (2023).


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## SEMESTER - III

**CORE VII: SOLID AND HAZARDOUS WASTE MANAGEMENT**

| Course Code | CC07 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | 1 | - | 5 | | |
| Pre-requisite | Idea regarding Solid wastes and its production | | | | | | | | |

### Course Objectives:

- *This course provides an overview of municipal solid waste (MSW), industrial waste and hazardous waste and their management*
- *It also deals with the planning, control measures, treatment methods, regulations in the management of solid and hazardous wastes*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Introduces the concept of solid waste and its sources along with the transfer stations | **K1,K2** |
| CO2 | Explains the MSW management and explains about its importance | **K4** |
| CO3 | An overview of different methods along with the advantagesand disadvantages could be understood | **K7** |
| CO4 | The impacts of the hazardous wastes on the environment alongwith the characteristics was made clear | **K1,K2** |
| CO5 | The student understands the importance of solid waste management in a systematic way | **K2,K4** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Solid Waste*** | Definition of Solid Waste – Types and Sources of Solid Waste - Domestic, Municipal, Agricultural, Industrial and Mining – Hazardous,Radioactive and Bio Medical Waste – Characteristics of Solid Waste – Density, Moisture, Heat Value, Energy Content – Components of Waste – Waste Generation Rates – Proximate and Ultimate analysisof solid waste. |
| **Unit II**<br>***Collection and Transfer Operation*** | Collection of Waste – Container System –Hauled and Stationary-Types of Collection Systems: Comparison of manual vs. automated collection systems– Collection Route – Optimizing Collection Routes: Techniques and technologies for route optimization to improve efficiency-Transfer Stations – Materials Recovery – Processing of Wastes – Screening, Shredding – Magnetic Separator – Air Classification – Economics of Recycling – Recycling and Carbon Credit – Electrical Energy Recovery – LCA (Life Cycle Assessment) – Case study of Aluminium cans recycling in Virginia. |
| **Unit III**<br>***Municipal Solid Waste Management*** | Solid Waste Processing Technologies – Open Dumping – Incineration – Types of Incinerators – Waste to Energy – Sewage Sludge – OnsiteIncinerators – Pyrolysis of Solid Waste – Sanitary Landfills – Landfill Regulation – Emission, Leachate and Monitoring – Composting - Aerobic Composting – Anaerobic Composting – Vermicomposting – Strategies of MSW – Solid Waste Management Rules MoEF (2016). |
| **Unit IV**<br>***Hazardous Waste*** | Hazardous Waste Definition – Sources – Characteristics of Hazardous Waste – Ignitability, Corrosivity, Reactivity, Toxicity – Types and Effect on Human Health – Biomedical Wastes, Radioactive Wastes and E-Wastes–Bioassay of Hazardous Waste – Biosensors - Risk Assessment Methods: Methods for assessing risks associated with hazardous waste exposure. |
| **Unit V**<br>***Hazardous Waste Management*** | Treatment Methods: Physico-Chemical treatment of Solid and Hazardous wastes–Neutralization – Oxidation – advanced Oxidation Process– Reduction – Precipitation & Stabilization–Soil Vapor Extraction–. Volatilization Process – Sorption–Waste Destruction Technology – Waste Construction Technology – Biological treatment of Solid and Hazardouswastes – Aerobic – Anaerobic, Bioremediation (Insitu and Exsitu), Biomethanation – Hazardous Waste Management Rules (1989). Comparative analysis of waste management strategies from various countries. Case Studies (Love canal episode, Sunflower Green, Karlsruhe City, Germany, Biomethanation plant (NISARGUNA at BARC) |

| | |
|---|---|
| *Current Contour* | Moving towards a Circular Economy in Solid Waste Management: Concepts and Practices-Institutional Waste Management-Characterization of Municipal Solid Waste (MSW): Global Trends - Search for Unique degradation enzyme and identification of genes responsible through data base-gene cloning to enhance composting process - Institutional Collaboration: The role of different stakeholders (government, NGOs, private sector) in waste management. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | S | M | M | S | S | M |
| **CO2** | M | M | M | M | S | S | L | M | M | M |
| **CO3** | S | S | S | S | S | S | M | M | L | S |
| **CO4** | S | S | M | M | S | S | M | S | S | M |
| **CO5** | M | M | M | M | S | S | L | M | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Environmental Engineering- A Design Approach, Sincero A.Pand Sincero G.A (2010), PHI learning pvt ltd, New Delhi
2. Environmental Engineering, Weiner, R.F and R. Matthews (2003),Reed Elsevier India Pvt. Ltd, New Delhi.
3. Environmental Science System and Solution, Mckinney, M.L.,and R.M Schoch (2003), Jones and Bartlett pub. USA
4. Handbook of Industrial and Hazardous Wastes Treatment, Wang,L.K., Y.T. Hung, H.H.Lo and C. Yapijakis (2004), Inc. New York
5. Handbook of Solid Waste Management and Waste Minimization Technologies, Cheremisinoff, N.P (2005), Reed Elsevier IndiaPvt ltd, New Delhi.


## Related Online Contents:

- https://www.dec.ny.gov/chemical/8732.html
- https://www.brighthub.com/environment/science-environmental /articles/92943.aspx
- http://www.aluminium.org/sites/.../LCA_Report_Aluminium_Association
- http://www.envfor.nic.in/divisions/hsmd/notif.html
- https://www.pdfdrive.net/handbook-of-solid-waste-management-e18718784.html

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# SEMESTER - III

## CORE VIII: ENVIRONMENTAL BIOTECHNOLOGY

| Course Code | CC08 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Basic understanding of microbiology, biotechnology, and environmental science | | | | | | | | |

### Course Objectives:

- *This course aims to introduce fundamentals of Environmental Biotechnology*
- *The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications*
- *The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| **CO1** | To describe suitable methods for characterizing the activity, function, diversity, and composition of microbial communities | **K1,K6** |
| **CO2** | To elucidate the microbial processes | **K2, K3** |
| **CO3** | Understand the growth requirements under laying different treatment techniques of microbes | **K1, K4** |
| **CO4** | To evaluate the potential for biodegradation of organic and inorganic pollutants, taking microbial and physical/chemical environments | **K5,K7** |
| **CO5** | Understand to analyze the chemical structure of the compounds | **K4, K7** |
| **K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation** | | |

| | |
|---|---|
| **Unit I**<br><br>***Introduction to Environment*** | Introduction to Environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology |

| | |
|---|---|
| **Unit II**<br><br>***Bioremediation*** | Bioremediation - fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ). Biodegradation pathways and microbial enzymes involved in pollutant breakdown- Biosorption and bioaccumulation mechanisms for heavy metals-Role of nanotechnology in enhancing bioremediation processes-Challenges and limitations of bioremediation in extreme environments. |
| **Unit III**<br><br>***Role of microorganism in bioremediation*** | Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages -Role of archaea and extremophiles in bioremediation of extreme environments (e.g., high salinity, temperature, pH)-Microbial consortia and synergistic interactions in pollutant degradation-Genetically engineered microorganisms (GEMs) for enhanced bioremediation efficiency-Enzymatic degradation: microbial enzymes involved in breaking down hydrocarbons, plastics, and other persistent pollutants- Microbial bioreactors for wastewater treatment and industrial effluent cleanup- Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization) - Phytoremediation and its applications in soil and water cleanup |
| **Unit IV**<br><br>***Biotechnology and agriculture*** | Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. *Trichoderma*, *Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application - Genetic engineering for crop improvement: drought resistance, pest resistance, and nutrient enhancement- Biotechnology in post-harvest management: biopreservation and reducing food wastage-Ethical considerations and biosafety of genetically modified organisms (GMOs) in agriculture. |
| **Unit V**<br><br>***Environmental Bioprocesses*** | Wastewater treatment-Microbial treatment processes: aerobic and anaerobic digestion, activated sludge process-Microbial fuel cells for wastewater treatment-Role of biofilms in wastewater treatment and biofilters-Bioreactors: design and applications in wastewater management-Application of biosorbents in heavy metal removal from wastewater-Emerging technologies in decentralized wastewater treatment: membrane bioreactors, constructed wetlands |
| ***Current Contour*** | GM crops of India and other Countries-Statistics - GM crops permitted in India- Pros and Cons of GM Crops-Case studies on Bioremediation-Impact of global warming on microbial ecosystems and Biodiversity-Applications of omics technologies |

in environmental biotechnology.

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | S | S | L | M | S | L | S | M | L |
| **CO2** | S | M | L | S | L | M | M | L | S | M |
| **CO3** | L | S | M | M | S | S | S | M | M | S |
| **CO4** | M | L | S | L | M | M | L | S | S | M |
| **CO5** | S | M | L | S | M | L | S | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Percentage of modification-186/29 x 100=78**

## Recommended References:


1. Environmental Biotechnology: Theory and Applications, G. M. Evans and J. C. Furlong (2003), Wiley Publishers.
2. Environmental Biotechnology: Principle & Applications, B.Ritmann and P. L. McCarty, (2000), 2nd Ed., McGraw Hill Science.
3. Environmental Biotechnology, Scragg A., (2005), Pearson Education Limited.
4. Biofiltration for Air Pollution Control, J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), CRC Press.
5. Biotechnology – A Multi-Volume Comprehensive Treatise, H. J. Rehm and G. Reed, (2001), Vol. 11, 2nd Ed., VCH Publishers Inc.


## Related Online Contents:

- https://onlinecourses.nptel.ac.in/
- https://www.nature.com/subjects/environmental-biotechnology
- https://www.biologydiscussion.com/biotechnology

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## SEMESTER - III

**CORE OPTIONAL 1: REMOTE SENSING AND GIS FOR ENVIRONMENTAL STUDIES**

| Course Code | CO03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Knowledge on basics of spatial data | | | | | | | | |

### Course Objectives:

- *This course provides an immense introduction regarding remote sensing and GIS along with the scope to explore, identify, and analyze the natural resources and present environment*
- *It also helps to document the changes in natural environment such as land, soil, water, forests, mountains etc*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand the concept of remote sensing technique | **K1, K2** |
| CO2 | Obtain knowledge about functional analysis of remote sensing technology | **K3, K5** |
| CO3 | Understand the data integration in GIS platform | **K2, K7** |
| CO4 | Identify the value and truthfulness of remote sensing data | **K7** |
| CO5 | Elaborate the need of remote sensing for sustainable development by proper planning. Know about the applications of remote sensing in environmental studies | **K6, K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Fundamentals of Remote Sensing*** | Definition and Fundamental Concepts of Remote Sensing- A Historic Perspective – Indian Remote Sensing Programme-Sun and Atmospheric Source of EM Radiations for RS - Physics of Remote Sensing - Electromagnetic Radiation and its Interaction with Atmosphere - Spectral Reflectance of Earth Materials and Vegetation – Concepts of Signature |

| | |
|---|---|
| **Unit II**<br><br>***Types of Remote Sensing*** | Remote Sensing Platforms-Aerial Photographs – Ground-level, Space-borne, Satellites- IRS series, LANDSAT series, SPOT series, High resolution satellites, character and applications, CARTOSAT series, IKONOS Series, QUICKBIRD series, Weather/Meteorological satellites, INSAT series, NOAA, GOES, NIMBUS Applications, Marine observation satellites OCEANSAT,Classification of Remote Sensors: Active and Passive Sensors – Selection of Sensor Parameter – Spatial Resolution – Spectral Resolution – Radiometric Resolution – Temporal Resolution - Data Products – Various Satellites in Orbits and their Sensors – Types of Orbits – Orbital Perturbations – The Space Craft. |
| **Unit III**<br><br>***Spatial Data Base*** | Cartography- Definition, Types of Maps - Map Reading and Scale – Map Projection - Basics and Fundamentals of Satellite Image Interpretation - Types of Image interpretation - Techniques of visual and digital image interpretation Techniques – Image Rectification and Restoration – Multispectral data analysis - Overview of image processing and image classification methods for feature extraction – Classification Accuracy Assessment. |
| **Unit IV**<br><br>***Geographic Information System (GIS) and GPS*** | Introduction of GIS - definition - Concept and components of GIS - Fundamental operations – An overview of existing GIS software's - Global positioning system and its applications**.** Types of data representation - Data input and output – Data model – Data entry – Data analysis and modeling – spatial data infrastructure - Coordinate geometry procedure - Manual digitizing – Scanning - Raster and vector data conversion - File management - GIS in Mapping Applications. |
| **Unit V**<br><br>***Environmental Applications*** | Ecosystem Studies – Environmental Impact Assessment – Land Use / Land Cover Change detection – Climate change monitoring – Natural resource Management- Environmental Monitoring – Pollution Mapping- Forestry Management- Disaster mitigation and management, Waste disposal - Dumping site selection - Composting yard – hazardous, biomedical and radioactive waste disposal / dumping sites – Health Management and disease mapping – Wetland management – Coastal zone management.<br>. |
| ***Current Contour*** | Discussion about Indian History of remote sensing. Web visualization practice of NASA and its activities. Specific discussion on climate for-casting sensors. Mini project on identification of polluted zones |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | M | S | S | M | M | S | M | S | S |
| **CO2** | M | M | S | M | M | S | S | S | M | L |
| **CO3** | M | S | M | M | S | M | M | M | S | M |
| **CO4** | M | M | S | M | M | M | M | S | M | M |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO5** | S | S | M | S | S | S | M | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Fundamentals of Remote Sensing (2nd edition), George Joseph (2008), Universities press, Hyderabad.
2. Remote Sensing and Image Interpretation, Lillie's T. M. and Kiefer R.W (2003), John Wiley and Sons.
3. Physical Principles of Remote sensing (3rd edition), Rees W.G (2013), Scott polar, Research Institute, University of Cambridge, New York.
4. Geographic Information Systems, David Martin (2013), Routledge.
5. GIS for Natural Resources and Disaster Management, Kumaraswamy K (2009) ,Dept. of Geography, Bharathidasan University
6. Fundamentals of Geographic Information Systems (3rd edition), Michael N. Demers (2008) , John Wiley & Sons.
7. Remote sensing and GIS: A practical approach, Bhatta, B. (2020). Oxford University Press. ISBN: 9780199458403.
8. Remote sensing and GIS for ecologists: Using open source software, Wegmann, M., Leutner, B., & Dech, S. (2019). Oxford University Press. ISBN: 9780198842234.
9. Remote sensing of the environment: An Earth resource perspective (2nd ed.), Jensen, J. R. (2014). Oxford University Press. ISBN: 9780134058160.


## Related Online Contents:

- www.isro.org
- www.nrsc.gov.in
- www.sac.gov.in
- www.esri.com
- www.erdas.com
- www.ittvis.com
- https://www.earthdata.nasa.gov/
- www.ittvis.com
- http://pcmas1.ccrs.nrcan.gc.ca/fundam/chapter1/chapter1 1 e.htm
- https://www.manage.gov.in/studymaterial/gis.pdf
- https://www.bbau.ac.in/dept/UIET/ce/Study%20Materials%20ECE%20402.pdf
- www.terraseer.com

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# SEMESTER - III

## CORE OPTIONAL 2: ENVIRONMENTAL INFORMATICS

| Course Code | CO03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | | 4 | | |
| Pre-requisite | Knowledge about data analysis and computer applications | | | | | | | | |

### Course Objectives:

- *The students will understand the application of information technology in natural sciences*
- *They will have a complete idea regarding the data on the biosphere and also the factors which affect it.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | To understand the importance of managing & analysing data related to environmental issues | **K1** |
| CO2 | To know the need for integrating data for decision making | **K3** |
| CO3 | Analyze complex environmental data | **K4** |
| CO4 | Ensure data inter-operability and could address issues related to data usage | **K5** |
| CO5 | Know the necessity of advancement in technology to overcome challenges. Face the challenges including handling complex datas | **K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Introduction to environmental informatics*** | Definition and Scope: Basics of environmental informatics and its role in environmental biotechnology. Environmental Data Types: Physical, chemical, biological, and ecological data. Historical Perspective: Evolution and milestones in environmental informatics. Interdisciplinary Nature: Integration with biotechnology, computer science, and environmental science. |

| | |
|---|---|
| **Unit II**<br>***Environmental Data Acquisition and Management*** | Data Collection Methods: Remote sensing, satellite imaging, field surveys, and sensors. Data Types and Sources: Geographic Information Systems (GIS). Environmental databases and repositories. Data Storage and Management: Data formats, metadata, and standards. Environmental data quality control and validation. |
| **Unit III**<br>***Tools and Techniques in Environmental Informatics*** | Geographic Information Systems (GIS): Fundamentals, tools, and applications. Remote Sensing: Basics, data interpretation, and applications in environmental monitoring. Environmental Modeling: Types of models (predictive, descriptive, and analytical). Applications in pollution control and ecosystem management. Big Data in Environmental Science: Concepts, analytics, and challenges. |
| **Unit IV**<br>***Applications of Environmental Informatics*** | Climate Change Studies: Data modeling for carbon footprints, greenhouse gas tracking, and climate modeling. Biodiversity Conservation: Habitat mapping, species monitoring, and genetic diversity assessment. Pollution Monitoring: Air, water, and soil quality assessment using informatics tools. Disaster Management: Early warning systems, risk assessment, and response planning. |
| **Unit V**<br>***BIOSA Emerging Trends in Environmental Informatics*** | Internet of Things (IoT): Applications in environmental monitoring and smart ecosystems. Artificial Intelligence and Machine Learning: Predictive analytics and decision-making. Blockchain in Environmental Science: Transparency in resource management and carbon credits. Sustainability Metrics: Indicators, tools, and informatics in sustainability science. Ethical and Social Aspects: Data privacy, accessibility, and policy implications. |
| ***Current Contour*** | Current state of informatics – Science challenges – Biological metadata standards – Dublin core, Darwin core, Thesauri, Informatic cycle, Geospatial technologies – basics concepts, mapping standards, mapping tools- International environmental informatics activities and challenges |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | M | M | S | S | M | S |
| **CO2** | S | S | M | M | S | S | S | S | S | S |
| **CO3** | S | S | M | M | S | S | M | S | S | S |
| **CO4** | S | M | S | S | S | S | S | M | M | S |
| **CO5** | S | S | S | S | M | S | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Environmental Informatics, James E. Frew and Jeff Dozier, (2012), Annu. Rev. Environ. Resour. 37:449–72
2. ESRI. 1998. *ESRI Shapefile Technical Description*. Redlands, CA: Environ. Syst. Res. Inst.
3. SQL multimedia and application packages (SQL/MM), Melton J, Eisenberg A. (2001) *IGMOD Rec.* 30:97–102
4. Projection and Datum Guidelines for DFG GIS Users, Patterson W. (2005) Sacramento: Calif. Dep. Fish Game.
5. Datums and Map Projections: For Remote Sensing, GIS and Surveying, Iliffe J, Lott R. (2008) Caithness, Scotl.: Whittles. 2nd ed.
6. Environmental Modelling: Finding simplicity in complexity, Wainwright, J. and Mulligan, M. (Eds.) (2003), John Wiley and Sons: Chichester.
7. Modelling of Environmental Processes. Applying soft computer methods, Bulla, M. (2004), state University of California, Incentives of Soft Computing.
8. Computerised Environmental Modelling: Apractical introduction using excel, Hardisty,J., Taylor, D. M and Metcalfe, S. E.(1993),. John Wiley and Sons: Chichester,
9. Environmental modelling a practical introduction, Barnsley, M.J. (2007), – CRC Press, at Taylor and Francis group, Boca Raton, London, NY.


## Related Online Contents:

- http://www.dfg.ca.gov/biogeodata/gis/pdfs/DFG_Projection_and_Datum_Guidelines.pdf

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## SEMESTER - III

**Elective A: BIOSAFETY AND BIOETHICS**

| Course Code | EC03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Knowledge about the safety measures and basic ethics in biology | | | | | | | | |

### Course Objectives:

- *This course helps the students to follow to the ethical values which are appropriate to impart ethical practices in the industries and field of research*
- *It gives clear idea about the biosafety of hazardous materials.*

### Expected Course Outcomes:
### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Know about the importance of biosafety | **K1, K2** |
| CO2 | Acquires knowledge regarding risk assessment & management | **K1, K2, K3** |
| CO3 | Understand about the ethics and its importance | **K2, K2** |
| CO4 | Discuss about the principles of various ethical theories | **K1, K2** |
| CO5 | Really know about the impacts of Biotechnology on the environment | **K4, K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Biosafety*** | Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India |
| **Unit II**<br>***Definition of GMOs & LMOs*** | Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; 7 Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol. |

| | |
|---|---|
| **Unit III**<br>***Bioethics*** | Concepts; Philosophical considerations; Epistemology of Science; Ethical Terms; Principles & Theories; Relevance to Biotechnology; Ethics and the Law Issues: Genetic Engineering, Stem Cells, Cloning, Medical techniques, Trans-humanism, Bioweapons; Research concerns - Animal Rights, Ethics of Human Cloning, Reproduction and Stem Cell Research; Emerging issues |
| **Unit IV**<br>***Intellectual Property Rights and Bioethics in Research*** | Intellectual Property Rights (IPR): Patents, copyrights, trademarks, and trade secrets in biotechnology. Patenting of Biotechnological Innovations: Issues and challenges (e.g., GMOs, bioinformatics tools). Ethics in Research and Publication: Plagiarism, authorship conflicts, and falsification of data. Importance of ethical review boards. Ethical Issues in Biotechnology Applications: Stem cell research, gene editing (CRISPR), and cloning. Genetic screening and its implications. |
| **Unit V**<br>***Emerging Topics in Biosafety and Bioethics*** | Biosafety in Industrial Biotechnology: Fermentation technology, biopharmaceutical production. Bioweapons and Bioterrorism: Ethical and Biosafety Concerns. Synthetic Biology: Risks, ethical concerns, and regulatory challenges. Bioethics and Sustainability: Role in addressing climate change, conservation, and biodiversity. Global Collaboration in Biosafety: Sharing resources, data, and knowledge for global health and safety. |
| ***Current Contour*** | Biosafety Guidelines for Handling and Processing Specimens associated with Corona Virus disease 2019 - Virus mutants- Pandemic and Epidemic |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | S | S | M | M | M | S | S | M | M |
| **CO2** | L | S | M | L | M | M | S | S | S | M |
| **CO3** | L | S | S | S | M | L | S | M | M | L |
| **CO4** | S | S | S | S | S | S | S | M | M | M |
| **CO5** | S | M | M | L | M | M | S | L | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Recommended References:**


1. Intellectual Property Rights, Brigitte Anderson, (2006) Edward Elgar Publishing, London.
2. Intellectual Property Rights and the Life Sciences Industries, Graham Dutfield, (2016), Routledge.
3. Intellectual Property, Elizabeth Verkey and Jithin Saji Isaac (2021), Eastern Book Company, India
4. Intellectual Property Rights, William Cornish, (200), OUP Oxford Pub.

## Related Online Contents:

- WIPO Intellectual Property Handbook- https://www.wipo.int/publications/en/details.jsp? id=275&plang=EN

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## SEMESTER - III

**Elective B: FOREST ECOLOGY AND ITS MANAGEMENT**

| Course Code | EC03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Basics of Different geographical features of the world | | | | | | | | |

### Course Objectives:

- *This course elaborates on the forest ecosystem including the climatic factors, nutrient cycles, biotic and abiotic components*
- *Further the types of forest present all over the world and in particular the forest types of India are explained*
- *Following which the ecology of the forest including the productivity is included.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | The learner understands about the microclimatic conditions of forests along with the biotic factors | **K1** |
| CO2 | The paper gives clarity about the different types of forests all over the world | **K1,K2** |
| CO3 | The impacts of deforestation and the merits of afforestation is also highlighted | **K4** |
| CO4 | The students are made to understand about the various acts available for the forest management is also explained | **K7** |
| CO5 | The final unit is a self-study unit which could motivate the student and paves way for him/her to understand further details regarding forest ecology | **K1** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Forest Ecosystem*** | Structure of forest ecosystem; forest microclimate - solar radiation Temperature, Atmospheric moisture, climate, soil, nutrient cycle, the soil - plant water cycle, and forest productivity. Animals and their roles in forest ecosystem. Macroevolution and reciprocal adaptations. Competition and survival, forest succession - stages of succession – Ecological/natural succession, climax forest, wind throw- Forest community. |
| **Unit II**<br><br>***Forest types*** | Major forest types of the world; forest types and forest cover of India - Tropical evergreen and semievergreen forests in India, Dry deciduous and dry evergreen forests, grassland, vegetation survey, optimum exploitation, Ecophysiology of forest trees: Characteristic of tropical trees; shoot growth in forest trees; phenology of trees; forest seed dormancy and germination; regeneration ecology of forest trees |
| **Unit III**<br><br>***Concepts of forest ecology*** | Significance of forest and its resources; Forest productivity (primary and secondary productivity), Measurement of forest productivity; Methods for enumeration of forest community structure, forest diversity indices and regeneration status; Nutrient cycling in forest- Carbon and Nitrogen cycle, human influences on global carbon and nitrogen cycles, major impacts of global ecological changes on forests. |
| **Unit IV**<br><br>***Forest Ecosystem management*** | History of forest management in India; joint forest management; forest fire; plantation forestry; application of remote sensing technique in forest ecology; deforestation and approaches to forestry conservation; Changing climate and their impact on forest and soil health. Afforestration - Social and agroforestry schemes. Forest fire-prevention, control and suppression, forest management practices and preservation of forests – Acts- Indian Forest Act 1927, Indian Wildlife (Protection) Act, 1972, Forest Conservation Act 1980, Forest Rights Act. |
| **Unit V**<br>***Wild life resources and conservation*** | Endangered mammals, reptiles, Birds and other animals and plant life. Wild life management and protection- Wild life projects in India. Role of governmental and nongovernmental organizations in Wild life protection. Role of IUCN, WWF and other international agencies in Wild life management - Sustainable Tourism and Wildlife Conservation- Technology in Wildlife Conservation: Use of drones, camera traps, and tracking devices in wildlife monitoring and conservation efforts. |
| ***Current Contour*** | Management of Commons and Common Property Resources (CPRs) and open access resources, forest management and sustainable livelihood strategies, forests and food security, participation of local people in ecotourism, land use change and forestry. Forest rights, customary rights of people, community participation, biodiversity and ethnobotany, Joint Forest Management, Social forestry programme, micro-level planning and participatory rural appraisal. Global environmental change and land use; poverty alleviation and forests, role of NGOs and other community based organizations in forest management |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | M | M | S | S | S | M | S | M | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | M | S | S | S | M | S | S | S | S | S |
| **CO5** | S | M | S | M | S | S | S | M | M | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**% of modification-76/400 x 100=20**

## Recommended References:


1. Forest ecology (4th edition), Barnes, BV; Zak, DR; Denton, SR and Spurr, SR (1998), John Wiley and Sons.
2. Forest Ecology, Burton V. Barnes, Donald R. Zak, Shirley R. Denton, Stephen H. Spurr. (1998), John Wiley & Sons.
3. A revised survey of the forest types of India (Reprinted 2004), Champion, HG. and Seth, SK (1968), Natraj Publicaiton, Dehradun.
4. State of forest report, FSI (2009), Forest Survey of India, Dehradun.
5. Forest ecology (2nd edition), Kimmins, J.P. (2004), Pearson Education.
6. Joint forest management in India. Ravindranath, NH (2004),Oxford University Press.
7. Forests in India - Environmental and production frontiers, Agarwala VP, (1985), Oxford and IBH publishing Co., New Delhi.
8. Tropical ecosystems. A Synthesis of Tropical ecology and conservation,
9. Balakrishnan M, Borgstorm R and S.W.Bie, (1994), Oxford and IBH publishing company and Pvt Ltd., New Delhi.
10. Environment and Pollution Law, Mohanty. SK, (2011), Universal Law Publishing Co.Pvt. Ltd.
11. Handbook of Environmental Law in India, Sahasranaman PB, (2008) Oxford University Press, India)
12. Environmental Law in India, Singh Gurdip, (2004), Mcmillan& Co.


## Related Online Contents:

- http://www.fao.org/forestry/Forestry.asp
- https://www2.helsinki.fi/en/researchgroups/forest-ecology-and-management/research
- www.fld.czu.cz
- *https://www.docsity.com* › forest-ecology-for-forestry-students.

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## SEMESTER - III

**Elective C: ENVIRONMENTAL GEOSCIENCES**

| Course Code | EC03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 4 | | |
| Pre-requisite | Knowledge regarding basic geological processes | | | | | | | | |

### Course Objectives:

- *To understand the basics of major geological processes occurring in the near surface of the Earth and its impact on the society and modification of natural environment*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Gain knowledge regarding origin & formation of Planet Earth | **K1** |
| CO2 | Understand the reactions involved in formation of soil& soil properties too | **K2** |
| CO3 | Know about the cycling elements in the biosphere | **K4** |
| CO4 | Will acquire clarity regarding the hydrogeology in particular | **K5** |
| CO5 | Know the importance of conservation of energy resources | **K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br><br>***Introduction to earth*** | Origin of earth. Primary geochemical differentiation and formation of core, mantle, crust, atmosphere and hydrosphere. Concept of minerals and rocks. Formation of igneous and metamorphic rocks. Controls on formation of landforms - tectonic including plate tectonic and climatic. Concept of steady state and equilibrium, Energy budget of the earth. Earth's thermal environment and seasons. Coriolis force, pressure gradient force, frictional force, geo-strophic wind field, gradient wind. Climates of India, western disturbances, Indian monsoon, droughts, El Nino, La Nina. Concept of residence time and rates of natural cycles. Geophysical fields. |

| | |
|---|---|
| **Unit II**<br>***Soil Chemistry*** | Weathering including weathering reactions, erosion, transportation and deposition of sediments. Soil forming minerals and process of soil formation, Identification and characterization of clay minerals, Soil physical and chemical properties, soil types and climate control on soil formation, Cation exchange capacity and mineralogical controls. |
| **Unit III**<br>***Chemical Composition*** | Geochemical classification of elements, abundance of elements in bulk earth, crust, hydrosphere and biosphere. Partitioning of elements during surficial geologic processes, Geochemical recycling of elements. Paleoclimate. |
| **Unit IV**<br>***Water Chemistry and Distribution*** | Distribution of water in earth, hydrology and hydrogeology, major basins and groundwater provinces of India, Darcy's law and its validity, groundwater fluctuations, hydraulic conductivity, groundwater tracers, land subsidence, effects of excessive use of groundwater, groundwater quality. Pollution of groundwater resources, Ghyben-Herzberg relation between fresh-saline water. |
| **Unit V**<br>***Natural Resources and Hazards*** | Natural resource exploration and exploitation and related environmental concerns. Historical perspective and conservation of non-renewable resources. Catastrophic geological hazards - floods, landslides, earthquakes, volcanism, avalanche, tsunami and cloud bursts. Prediction of hazards and mitigation of their impacts. |
| ***Current Contour*** | Genesis of regional climates and their global distribution. Emphasis on world regional climatology. Secondary topics include applied climatology and climate change |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | M | S | M | S |
| **CO3** | S | S | M | S | S | S | M | S | S | S |
| **CO4** | S | S | M | S | S | M | S | L | L | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Abbot, P.L. (2006). *Natural Disasters* , McGraw-Hill
2. Foley, D., G. McKenzie, and R. Utgard (2008). *Investigations in Environmental Geology, 3rd ed.*, Pearson Prentice Hall, 320 p.
3. Harrad, S. (2008). *Student projects in environmental science.* Chichester, West Sussex, England: John Wiley.
4. Hudson, T. (2011). *[Hudson, 2011]* , Pearson Prentice Hall, 576 p.
5. Hyndman D. and D. Hyndman (2010). *Natural Hazards and Disasters*. Brooks/Cole, 592
6. Keller E.A. and D.E. DeVecchio (2011). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes (3rd Ed.). Pearson Prentice Hall, 528 p.

7. Montgomery, C. (2011). *Environmental Geology 9th Ed*. McGraw-Hill
8. Reichard, J.S. (2011). *Environmental Geology*. McGraw-Hill Publishers. New York, NY.

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## SEMESTER - III

**Laboratory Course III: REMOTE SENSING AND GIS FOR ENVIRONMENTAL STUDIES**

| Course Code | LC03 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | - | - | 4 | 4 | | |
| Pre-requisite | Understanding of geography and computer applications | | | | | | | | |

### Course Objectives:

- *To assess environment changes and to monitor level of pollutants for better environmental management*
- *Introduce students to the fundamental concepts of remote sensing and GIS*
- *Develop familiarity with different types of remote sensing data and GIS software*
- *Train students in performing spatial analysis, including overlay, etc..*
- *Explore different applications of remote sensing and GIS, such as environmental monitoring, urban planning and disaster management.*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Students will explore on advance techniques like GIS and Remote sensing for environmental studies | **K1,K4** |
| CO2 | The student could identify the value and truthfulness of remote sensing data | **K4** |
| CO3 | The learner could analyze the cost effectiveness of remote sensing data | **K3, K4** |
| CO4 | The student could understand the advantages of remote sensing | **K2, K6** |
| CO5 | Students will be able to apply remote sensing and GIS techniques to real-world problems in fields such as environmental monitoring, urban planning, and disaster management | **K6, K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

**EXPERIMENTS**

1. Global Positioning System
2. Geo referencing process for mapping
3. Preparation of base map, digitizing and editing
4. Spatial data input and processing
5. Creation of GIS database
6. Preparation of drainage network map
7. Satellite image interpretation Techniques
8. Preparation of forest classification map

9.Land Use /Land Cover map preparation

10.Layout Preparation (Legend scale, scale text, north arrow)

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | M | S | M | M | M | M | S | M | S |
| **CO2** | S | S | M | M | M | L | S | S | S | S |
| **CO3** | S | S | M | M | S | S | M | M | M | M |
| **CO4** | M | M | S | S | M | M | M | M | S | M |
| **CO5** | M | M | M | S | M | M | S | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:

### Web Links

- https://www.nrsc.gov.in/
- https://www.arcgis.com/index.html
- https://www.isro.gov.in/
- https://bhuvan.nrsc.gov.in/home/index.php

## SEMESTER - III

**Elective: BIO ENTREPRENEURSHIP**

| Course Code | EIBC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 | - | - | 3 | | |
| Pre-requisite | | Knowledge about green products | | | | | | | |

### Course Objectives:

- *The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards*

### Expected Course Outcomes:

### On the completion of the course the student will be able to

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Students could gain entrepreneurial skills, understand the various operations involved in venture creation | **K3,K7** |
| CO2 | The learner could identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies | **K2,K1,K7** |
| CO3 | The knowledge regarding green products will be acquired by the learners | **K1** |
| CO4 | The possibility of collaborations & partnerships will be understood by the students | **K2,K6** |
| CO5 | The student will understand about the regulatory compliances too | **K2,K7** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>***Innovation and entrepreneurship in bio-business*** | Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of biosector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies. |
| **Unit II**<br>***Bio markets - business strategy and marketing*** | Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills |
| **Unit III**<br>***Green Products*** | Definition, Characteristics, Advantages, thinking green - Life cycle analysis, Green home- solar panel, LEED certification, water recycling, solid waste management, Terrace garden- Self sustained life style, Rain water harvesting Systems- Waste to wealth. |
| **Unit IV**<br>***Finance and accounting*** | Business plan preparation including statutory and legal requirements, Business feasibility study and financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology. |
| **Unit V**<br>***Technology management*** | Technology – assessment, development & upgradation, managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP). |
| ***Current Contour*** | Technology transfers from lab to land-Patenting, Marketing, Promoting and Sustaining-Case studies. |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | S | M | S | S | M | S | M | S | S |
| **CO2** | S | M | S | M | M | M | S | M | M | S |
| **CO3** | M | S | M | M | S | M | M | S | S | M |
| **CO4** | M | M | S | M | M | M | M | M | M | M |
| **CO5** | S | S | M | S | M | S | M | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences.Adams, D. J., & Sparrow, J. C. (2008). Bloxham: Scion.
2. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam:Shimasaki, C. D. (2014), Elsevier. Academic Press is an imprint of Elsevier.
3. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge, Onetti, A., & Zucchella, A,(2018),Routledge
4. Innovation, Commercialization, and Start-Ups in Life Sciences. Jordan, J. F. (2014). London: CRC Press
5. The Dynamics of Entrepreneurial Developmentand Management. Desai,V(2009),New Delhi, Himalaya Pub house.


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## SEMESTER - III

**Value added course: WASTE TO WEALTH**

| Course Code | VAC2 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 30 | | | 2 | | |
| Pre-requisite | Basic concepts of Environmental Science, Microbiology, and Chemistry- | | | | | | | | |

### Course Objectives:

| | |
|---|---|
| • *To introduce students to the principles of converting waste into valuable products using sustainable technologies.* | |
| • *To provide knowledge on biotechnological, chemical, and physical methods for waste valorization.* | |
| • *To develop skills for designing, evaluating, and optimizing waste-to-wealth processes for environmental and economic benefits.* | |

### Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Understand the concept of waste as a resource and the importance of circular economy | **K1,K2** |
| CO2 | Evaluate different waste valorization technologies for industrial, agricultural, and municipal wastes | **K2,K4 &K6** |
| CO3 | Apply microbial, enzymatic, and thermochemical approaches for converting waste into energy and useful products | **K3,K4 &K6** |
| CO4 | Analyze and design integrated waste management and valorization systems with sustainability indicators | **K4 ,K5 &K7** |
| CO5 | Critically assess techno-economic feasibility, environmental impact, and policies for waste-to-wealth initiatives | **K6 & K7** |
| **K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation** | | |

| | |
|---|---|
| **Unit I**<br>***Introduction to different wastes*** | Concept of waste as a resource – Waste hierarchy and 5Rs (Reduce, Reuse, Recycle, Recover, Redesign) – Circular economy and sustainable development goals (SDGs) – Types and sources of waste: agricultural, municipal solid waste (MSW), industrial, e-waste, biomedical – Environmental, social, and economic impacts of improper waste disposal – Policy framework and national initiatives on waste-to-wealth. |
| **Unit II**<br>***Biological Conversion Technologies*** | Composting and vermicomposting – Anaerobic digestion and biomethanation for biogas and biohydrogen production – Microbial fuel cells and bioelectrochemical systems – Conversion of agro-residues into biofertilizers, biopolymers, and enzymes – Case studies: BARC–NISARGUNA biogas plant, community-level composting initiatives. |
| **Unit III**<br>***Thermochemical and Physico-Chemical Methods*** | Pyrolysis, gasification and hydrothermal carbonization – Refuse-derived fuel (RDF) and waste-to-energy plants – Chemical recovery processes such as transesterification for biodiesel and acid/alkali hydrolysis for value-added chemicals – Biochar production and applications in agriculture and water treatment – E-waste recycling with focus on metal recovery and safe disposal practices. |
| **Unit IV**<br>***Industrial Applications and Value-Added Products*** | Recovery of bio-based products such as organic acids, solvents, pigments and biosurfactants – Production of single-cell proteins, algae-based biofuels and nutraceuticals – Conversion of plastics and polymers into useful chemicals – Waste-derived construction materials including fly ash bricks and geopolymer cement – Case studies of successful waste-to-wealth enterprises in India and other countries. |
| **Unit V**<br>***Sustainability, Economics, and Future Perspectives*** | Techno-economic feasibility and life-cycle assessment of waste-to-wealth projects – Carbon credits, green business models and entrepreneurship in waste valorization – Smart technologies including AI, IoT and Industry 4.0 in waste management – Integration of waste-to-wealth in smart cities and rural development – Future scope including biorefineries, circular bioeconomy and global challenges. |
| ***Current Contour*** | Microbial Production of Value-Added Metabolites – Metabolic Engineering and Process Intensification – Reactor Design and Bioreactor Optimization – Product Recovery and Purification Techniques – Biorefineries and Circular Bioeconomy Models |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | S | M | S | M | M | S | S | S | M |
| **CO2** | M | S | S | S | S | S | M | S | M | M |
| **CO3** | S | M | S | S | M | S | S | M | S | M |
| **CO4** | S | S | M | S | M | S | S | M | S | M |
| **CO5** | M | M | S | S | S | M | M | S | S | M |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1.Bhatia, S.C. (2018). *Waste to Wealth: Energy from Waste*. CRC Press, Boca Raton.

2.Satyanarayana, T., Johri, B.N. and A. Prakash. (2012). *Microorganisms in Sustainable Agriculture and Biotechnology*. Springer, New York.

3.Sridhar, M.K.C. and G.O. Adeoye. (2003). *Waste to Wealth: Value Recovery from Wastes*. Pan African University Press, Ibadan.

4.Singh, R.P. and P. Singh. (2022). *Global Waste to Resource: Waste-to-Wealth Approaches*. Springer, Singapore.

5. Rhyner, C.R., Schwartz, L.J., Wenger, R.B. and T.J. Kohrell. (1995). *Waste Management and Resource Recovery*. CRC Press, Boca Raton.


## Related Online Contents:

https://ilsr.org/articles/transforming-communitys-waste-to-wealth/ ¬
https://link.springer.com/article/10.1007/s43615-022-00225-2 ¬
https://www.sciencedirect.com/science/article/pii/S2666845924001417 ¬
https://www.sciencedirect.com/science/article/pii/S2665972725001874
https://www.e3s-conferences.org/articles/e3sconf/abs/2023/90/e3sconf_icsdg2023_01035/e3sconf_icsdg2023_01035.html "

## E- Books

- https://library.oapen.org/bitstream/20.500.12657/86407/1/9781800084650.pdf
- https://shop.elsevier.com/books/waste-valorization-for-bioenergy-and-bioproducts/ong/978-0-443-19171-8
- https://link.springer.com/book/10.1007/978-1-0716-4646-5
- https://library.oapen.org/handle/20.500.12657/94012
- https://link.springer.com/book/10.1007/978-1-0716-4490-4
- https://archive.org/details/wastetowealthcir0000lacy
- https://library.oapen.org/bitstream/20.500.12657/86407/1/9781800084650.pdf
- https://direct.mit.edu/books/oa-monograph/chapter-pdf/2246871/c001000_9780262369503.pdf
- https://library.oapen.org/bitstream/20.500.12657/95754/1/9781003433729_10.4324_9781003433729-1.pdf
- https://api.developmentaid.org/api/frontend/cms/file/2019/08/WTEfull-compressed.pdf

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## SEMESTER – IV

### PROJECT WORK

| Course | Course Code | Course Type | Hours | Credits | Syllabusversion |
|---|---|---|---|---|---|
| 22 | CP01 | Core - Research | 30 | 12 | 2025-2026 |

## SEMESTER - II

**Non Major Elective I: CONTEMPORARY ENVIRONMENTAL ISSUES**

| Course Code | NMEC01 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | 1 | - | 2 | | |
| Pre-requisite | Knowledge on issues related to Environment | | | | | | | | |

### Course Objectives:

- *The students will be exposed to different important issues of environment and about their impact on the environment*
- *They will be able to widen their knowledge regarding various environmental issues and could spread awareness about the same to the readers*

### Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Describe the sources and effects of various pollutants with respect to water including both fresh water and marine water. | **K1, K2** |
| CO2 | Review the established methods employed for controlling different types of pollution. Assess the environmental impacts of noise, thermal and radioactive pollution. | **K2, K7** |
| CO3 | Evaluate the scientific basis underlying in controlling of all pollutants and to take suitable measures for all pollution control. | **K7** |
| CO4 | Improve the Knowledge on the case studies, which could highlight the real danger of pollution. Propose ideas to control environmental pollution with respects professionalism, ethics and moral. | **K6** |
| CO5 | Would get an awareness regarding various pollution and understand about their ill effects. Can really come out with research ideas to facilitate sustainability. | **K6, K5** |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

| | |
|---|---|
| **Unit I**<br>**Environmental issues related to Water Pollution** | Water Pollution – Definition – Fresh water and Marine - Sources (Natural and Anthropogenic), Pollutants (anions, cations, microbiological, Persistant Organic Pollutants) , Effects – Control of water Pollution- Primary, secondary and Tertiary treatment – Eutrophication, Oxygen sag curve, Biomagnification- Minamata and Itai- Itai disease, Exxon Valdez and Torrey canyon oil tanker accidents |

| | |
|---|---|
| **Unit II**<br>**Environmental issues related to Air Pollution** | Air Pollution – Definition, Sources (Natural and Anthropogenic), Pollutants (Particulate and gaseous) Effects – Control of Air Pollution- Electrostatic precipitator, Cyclones, Bag filter, Scrubbers – Ozone layer depletion, Acid Rain, Global warming, Green house effect, Photochemical smog- Bhopal Gas Tragedy, Chernobyl Disaster |
| **Unit III**<br>**Environmental issues related to Solid Waste Pollution** | Solid waste Pollution – Definition, Sources (Domestic, Municipal, agricultural, Commercial and Industrial), Pollutants (Organic waste, E-waste, biomedical wastes, fertilizers, pesticides) Method of disposal- Open dumping, Sanitary landfills, Incineration, Pyrolysis, Composting and Vermicomposting-Love canal episode |
| **Unit IV**<br>**Environmental issues related to Biodiversity Conservation** | Biodiversity- Definition, types (Genetic, species) – Values of Biodiversity (Direct and indirect) loss of biodiversity –reasons, effects - Conservation of biodiversity- Insitu and exsitu, Ramsar sites in India. Forest Conservation – Chipko movement, Appiko movement, Project tiger, Project Elephant. |
| **Unit V**<br>**Environmental issues related to Thermal, Noise and Radioactive Pollution** | Thermal, Noise and Radioactive Pollution – Definition, Sources and Types of Pollutants - Effects - Fukusima Daiichi nuclear disaster |
| **Current Contour** | United Nations SDGs - 17 goals and themes – Environmental awareness levels-1,2,3 and 4 – Laws and Policies for Environmental Management – EIA – Energy auditing |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | S | M | M | M | M | S | M | M | S |
| **CO2** | S | M | S | M | M | M | M | S | M | M |
| **CO3** | M | S | M | S | S | S | S | S | S | M |
| **CO4** | M | M | S | M | M | M | M | M | M | M |
| **CO5** | S | M | M | S | L | S | M | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

**Recommended References:**


1. Environmental pollution and its control, Abbasi. S. A (1998) . Cogent publications (P) Limited. Delhi.
2. Managing Environmental Pollution, Andrew former (2003) Routledge Publisher, London.
3. Environmental pollution and its control, Bhatia H.S (1998) Golgotia publications (P) Limited, New Delhi.

4. Environmental Science, Cunningham, W.P. and W.B. Saigo (2005) McGraw Hill, New York.
5. Environmental Chemistry and pollution control, Dara SS (1998) Textbook of Chanthan company
6. Environmental Chemistry, De A.K (1987) Wiley Eastern Ltd, New Delhi.
7. Environmental Science and Engineering, Dr.Suresh K. Dhamaja (2005)
8. Agroclimoitic approach to water management, Geetha lakshmi V, Jagannathan R, Thavaprakash N (2007) Coimbatore.
9. Fundamentals of Environmental Pollution, Kannan K (1991) S Chand Co, New Delhi.
10. Environmental Chemistry, Manahan (2000) CRC press, U.S
11. Air Pollution, Rao M.N and H.V.N Rao (1989) Tata Mcgraw Hill Publishing Co. Ltd, New Delhi.
12. Chemistry for Environmental Engineering and Science, Sawyer C.N., Mc Carty P.L., and Parkin,G.F (2003) Tata McGraw-Hill Publishing Company Ltd., New Delhi.
13. Soil and Noise Pollution, Sharma, B.K. and H.Kaur (1994) Goel Publishing House.
14. Water Pollution, Sharma, B.K. and H.Kaur (1994) Goel Publishing House.

## Related Online Contents

- https://books.google.co.in/books/about/Environmental_ Pollution.html?id=GQftLn 7u8igC& redirges=y
- https://books.google.co.in/books/about/Air_Pollution. html?id=hDoN0SPgLksC
- http://www.naturefirstusa.org/environmental pollution/ Environmental Pollution - Health and Toxicology - Google Books.htm#PPR11,M1
- https://authors.library.caltech.edu/25069/1/AirPollution88.pdf
- http://payesh.saba.org.ir/saba_content/media/image/2016/11/ _orig.pdf

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## SEMESTER - III

**Non Major Elective II: ENERGY AND ENVIRONMENT**

| Course Code | NMEC02 | Course Type | Core | L | T | P | C | Syllabus version | 2025-2026 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 3 | - | - | 2 | | |
| Pre-requisite | Basic idea regarding different energy resources | | | | | | | | |

### Course Objectives:

- *The students will be exposed to different types of energy resources and also their significance*
- *The students will be able to widen their knowledge about the advantages and limitations regarding the usage of different energy resources.*
- *Students also will be exposed to all the concepts of Environment, Renewable and Non-renewable Energy, etc*

### Expected Course Outcomes:

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOME | KNOWLEDGE LEVEL |
|---|---|---|
| CO1 | Describe basic energy concepts and throws light on conventional and renewable energy technologies and their applications | **K1, K2** |
| CO2 | Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption, and climate change and reflect on energy costs | **K2** |
| CO3 | Analyze the consequences of today's energy consumption | **K4, K7** |
| CO4 | Understand the need for alternate energy resources | **K2, K6** |
| CO5 | Promote and advice the use of green energy in all possible places | **K1, K7** |
| **K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation** | | |

| | |
|---|---|
| **Unit I**<br><br>**Energy Availability and Usage** | Earth's energy source - Earth's energy balance – Energy reserves and usage – determinants of growth in energy use – Energy Security-Energy usage pattern of the world and India. |

| | |
|---|---|
| **Unit II**<br>**Non Renewable Energy Resources** | Fossil fuels- The three kings- Coal, Oil and Natural gas – Formation, Calorific value, Physico-chemical properties of fuel and energy content of fuel- Advantages and limitations – Greenhouse gases and Global warming – Nuclear energy – availability and limitations |
| **Unit III**<br>**Renewable Energy Resources** | Non-conventional energy resources- Principle of energy production and selected appliances - Principles of generation of hydro-power, tidal energy, ocean thermal energy conversion, wind power, geothermal energy, solar energy (solar collectors, photo-voltaic modules, solar ponds)–Advantages- Economic and Environmental considerations. |
| **Unit IV**<br>**Alternative Fuels** | Ethanol as a fuel, Biobutanol, Biodiesel, Lignocellulosic fuels, Dimethyl ether, sustainable aviation fuel, methanol– Production, benefits, Future possibilities, energy efficiency |
| **Unit V**<br>**Waste to Energy** | Biomass Energy Source- Microbial Fuel Cells- Fundamentals and their types (algal, Fungal, animal waste, organic waste, wastewater based)- Cost benefit analysis- Future perspectives. |
| **Current Contour** | Electric driven cars, two wheelers – Green buildings- Energy auditing- sustainable energy consumption – Sustainable Development Goals |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | M | S | M | M | M | M | M | S | M |
| **CO2** | M | M | M | S | M | M | M | S | S | S |
| **CO3** | S | S | M | M | S | S | M | M | M | S |
| **CO4** | M | M | S | M | S | M | S | M | M | M |
| **CO5** | M | M | M | S | M | L | S | M | M | S |
| | | | | | | | | | | |
| **S-Strong; M-Medium; L-Low** | | | | | | | | | | |

## Recommended References:


1. Environmental chemistry, Colin Baird and Michael Cann (2008), W. HFreeman and company, England.
2. Environmental Science- towards a sustainable future, Wright, R.T and D.F.Boorse (2011), PHI learning pvt ltd., New Delhi.
3. Advances in Solar Energy Technology, Garg, H.P. (1990), D. Reid Publishing Company, Tokyo.
4. Alternative liquid fuels, Desai,A.V. (1990), New Age International (p) Ltd.,
5. Biomass for Energy in the Developing Countries, Current Roles, Potential, Problems, Prospects, D.O.
   Hall, G.W. Barnard, and P.A. Moss (1982), Pergamon Press Ltd.,
6. Biomass- Regenerable Energy, D.O. Hall & R.P. Overend (1987), John Wiley.
7. Biotechnology and other Alternative Technologies, Chakraverty, A. (1998.). Oxford and IBH Publishing Co. Pvt. Ltd.,
8. Critical Reflections on Nuclear and Renewable Energy, Way Kuo (2014), Scrivener Publishers Wiley.
9. Non-Conventional Energy Sources, Rai, G.D. (2001), Khanna Publishers, New Delhi.
10. Solar Energy, Sukhatme, S.P. (1996), Tata Mc Graw Hill Publishing Company.
11. Wind Energy Conversion Systems, FrerisL.L. (1990) Prentice Hall
12. Energy and the Environment" by James A. Fay and Dan S. Golomb.
13. Environmental Science- towards a sustainable future, Wright, R.T and D.F.Boorse (2011), PHI learning pvt ltd., New Delhi.
14. Robert A. Ristinen, Jack J. Kraushaar, Jeffrey Brack, Energy and the Environment, wiley Publication
15. Energy at the Crossroads: Global Perspectives and Uncertainties , Vaclav Smil (2024).
16. Renewable Energy: Power for a Sustainable Future ,Godfrey Boyle (2023).


## Related Online Contents:

- http://www.ener-supply.eu/downloads/ENER_ andbook _en.pdf
- http://bieap.gov.in/Pdf/Nonconventionalenergysourses.pdf
- https://afdc.energy.gov/fuels/

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