गोंय विद्यापीठ
ताळगांव पठार,
गोंय – ४०३ २०६
फोन : +९१-८६६९६०९०४८

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GU/Acad –PG/BoS -NEP/2025-26/253 Date: 17.07.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Master of Science in Environmental Science** Programme approved by the Academic Council in its meeting held on 13th & 14th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Earth, Ocean and Atmospheric Sciences and Principals of the affiliated Colleges offering the **Master of Science in Environmental Science** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.07.17 17:30:35 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Earth, Ocean and Atmospheric Sciences, Goa University.
2. The Vice-Dean (Academic), School of Earth, Ocean and Atmospheric Sciences, Goa University.
3. Principal of affiliated College offering the Master of Science in Environmental Science Programme.

Copy to:
1. Chairperson, BoS in Environmental Science, Goa University.
2. Programme Director, M.Sc. Environmental Science, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE PROGRAMME

(Effective from the Academic Year 2025-2026)

ABOUT THE PROGRAMME

Environmental science has conventionally studied physical, chemical and biological processes in the Earth system (Lithosphere, hydrosphere, atmosphere, biosphere and cryosphere). Increasingly, it now incorporates nature-human interactions and the social, political and cultural processes which impact the planet. The anthropogenic pressures on the ecological processes have forced disciplinary boundaries to merge and a student of environmental science must understand the complex relationships that drive nature-human interactions. Sustainability is one of the grand challenges that human survival faces on planet Earth.

Goa University has designed a unique two-year postgraduate programme in Environmental Science keeping the above grand challenge in mind. The programme is hosted by the School of Earth Ocean and Atmospheric Sciences (SEOAS) in collaboration with other schools across the University such as School of Biological Sciences and Biotechnology, School of Chemical Sciences, Goa Business School, School of Physical and Applied Sciences, D.D. Kosambi School of Social Sciences and Behavioural Studies and Manohar Parrikar School of Law, Governance and Public Policy. This multidisciplinary programme will teach students how to combine skills and knowledge from a variety of domains. It will allow students to explore courses from a large number of disciplines and skill themselves in a manner that they feel best suits them for their knowledge pursuits.

Eligibility: Graduate in any science subject including Medicine and B. Tech.

OBJECTIVES OF THE PROGRAMME

- The programme aims to provide a holistic approach to understand environmental issues and undertake environmental impact assessment studies with diverse perspectives, frameworks and using multiple data sources.
- Field and laboratory-based work will help students to experience conservation and management of varied habitats, understand response of biotic components to a changing climate, and gain insights on land formations and social structures.

Approved by: Academic Council on 13th & 14th June 2025

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	To provide a holistic view of the environment, multi-disciplinary understanding on the causes, impacts of environmental issues, their management and conservation.
PSO 2.	To monitor environmental quality through advanced analytical techniques for providing baseline information on the effect of land-based activities on groundwater source and coastal ecosystems.
PSO 3.	To acquaint/train the students for Environmental Impact Assessment studies as per the Ministry of Environment, Forest and Climate Change (MoEFCC) guidelines from time to time.
PSO 4.	To generate awareness among the student community about the linkages between the environment and ecosystem services to support livelihood that enable upliftment of socio-economic status.
PSO 5.	To enable an understanding of spatial data integration and interpretation for environmental conservation.
PSO 6.	To apply theoretical insights to real-world environmental challenges, foster critical thinking, ethical reasoning, and informed action for sustainable environmental futures.

PROGRAMME STRUCTURE
Master of Science in Environmental Science
Effective from Academic Year 2025-2026

Bridge Course			
Sr. No.	**Course Code**	**Title of the Course**	**Credits**
1	ENV-1000	Fundamentals of Environmental Science	2T

Note: The bridge course will be offered to students coming from diverse academic backgrounds to gain foundational knowledge in Environmental Science.

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ENV-5000	Environmental Chemistry	3T	400
2	ENV-5001	Environmental Chemistry Practical	1P	400
3	ENV-5002	Environmental Biology and Ecology	3T	400
4	ENV-5003	Environmental Biology and Ecology Practical	1P	400
5	ENV-5004	Environmental Geology and Soil Science	3T	400
6	ENV-5005	Environmental Geology and Soil Science Practical	1P	400
7	ENV-5006	Atmospheric Science and Climate Change	3T	400
8	ENV-5007	Atmospheric Science and Climate Change Practical	1P	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ENV-5201	Coastal Habitats and Processes	3T	400
2	ENV-5202	Coastal Habitats and Processes Practical	1P	400
3	ENV-5203	Mangrove Ecosystem and Biodiversity	3T	400
4	ENV-5204	Mangrove Ecosystem and Biodiversity Practical	1P	400
5	ENV-5205	Remote Sensing Techniques and GIS	3T	400
6	ENV-5206	Remote Sensing Techniques and GIS Practical	1P	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

Note: Students opting for a 3-credit DSE theory course are required to take the corresponding 1-credit practical course.

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ENV-5008	Analytical Techniques	3T	500
2	ENV-5009	Analytical Techniques Practical	1P	500
3	ENV-5010	Environmental Microbiology	3T	500
4	ENV-5011	Environmental Microbiology Practical	1P	500
5	ENV-5012	Environmental Toxicology and Risk Assessment	3T	500
6	ENV-5013	Environmental Toxicology and Risk Assessment Practical	1P	500
7	ENV-5014	Waste Management	3T	500
8	ENV-5015	Waste Management Practical	1P	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ENV-5207	Environment Ethics	4T	400
2	ENV-5208	Environmental Issues and Perspectives	4T	400
3	ENV-5209	Sustainable Development and Resource Management	3T	400
4	ENV-5210	Sustainable Development and Resource Management Practical	1P	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

Note: Students opting for the 3-credit DSE theory course are required to take the corresponding 1-credit practical course.

Blooms Taxonomy Cognitive Levels	
Cognitive Level	**Notations**
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

BRIDGE COURSE

Title of the Course	Fundamentals of Environmental Science
Course Code	ENV-1000
Number of Credits	02
Theory/Practical	Theory
Level	100
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	Yes (Bridge Course)
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Understand and evaluate key environmental issues. • Analyze ecological systems and biodiversity. • Integrate fundamental principles of chemistry, physics, and biology. • Examine environmental pollution and control methods.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the scope, importance, and interdisciplinary nature of environmental science.	PSO 1
	CO 2. Identify and describe key environmental issues.	PSO 1
	CO 3. Explain the structure and functioning of ecosystems and ecological interactions.	PSO 1

	CO 4. Identify major global biomes and biodiversity hotspots.		PSO 1	
	CO 5. Apply basic chemical principles relevant to environmental systems.		PSO 1	
	CO 6. Identify sources, types, and impacts of various types of pollutants and evaluate practical solutions to address contemporary environmental problems.		PSO 1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	*Introduction to Environmental Science* Definition, scope, and importance; Interdisciplinary nature; Key environmental issues such as climate change, ozone depletion, global warming, loss of biodiversity, pollution, deforestation, sea level rise, ocean acidification, resource depletion, waste management, and overpopulation; Sustainable development goals (SDGs).	**15**	CO1, CO2	K2
	Basics of Ecology and Biodiversity: Ecosystem structure and function; Food chains, webs, and ecological pyramids; Biomes and biodiversity hotspots; Conservation strategies.		CO3, CO4	K2
Module 2:	*Fundamentals of Chemistry, Physics & Biology* Chemistry: pH, organic/inorganic chemistry, redox, water and soil chemistry; Physics: energy, radiation, thermodynamics; Biology: cell structure, genetics, evolution, microbiology relevant to the environment.	**15**	CO5	K3
	Environmental Pollution & Control Air, water, soil, and noise pollution: sources, effects, mitigation; Solid and hazardous waste management; Case studies of major environmental disasters; Solutions to environmental issues.		CO6	K2, K5
Pedagogy:	Lectures/ tutorials/ assignments / case study analysis/ group discussions			
References/ Readings:	1. Botkin, D. B., & Keller, E. A. (2014). *Environmental science: Earth as a living planet* (9th ed.). Wiley, Hoboken, NJ. 2. Cunningham, W. P., & Cunningham, M. A. (2017). *Principles of environmental science: Inquiry and applications* (8th ed.). McGraw-Hill Education. New York, NY, USA.			

	3. Dash, M. C. (2010). *Fundamentals of ecology*. Tata McGraw-Hill. New Delhi, India. 4. De, A. K. (2006). *Environmental studies* (2nd ed.). New Age International. New Delhi, India. 5. Manahan, S. E. (2017). *Environmental chemistry* (10th ed.). CRC Press. Boca Raton, FL 6. Miller, G. T., & Spoolman, S. (2018). *Living in the environment* (19th ed.). Cengage Learning. Boston, MA, USA. 7. Misra, S. P., & Pandey, S. N. (2010). *Essential environmental studies*. Ane Books. New Delhi 8. Primack, R. B. (2014). *Essentials of conservation biology* (6th ed.). Sinauer Associates/Oxford University Press, Sunderland, MA, USA. 9. Rajan, S. D. (2019). *Environmental studies* (2nd ed.). Pearson India, Chennai, India. 10. Sharma, B. K. (2016). *Environmental chemistry and pollution control* (Rev. ed.). Krishna Prakashan Media, Meerut, India. 11. Smith, R. L., & Smith, T. M. (2015). *Elements of ecology* (9th ed.). Pearson, Boston, MA, USA. 12. Solomon, E. P., Berg, L. R., & Martin, D. W. (2015). *Biology* (10th ed.). Cengage Learning, Boston, MA, USA.
Web Resources:	1. IPCC Reports (https://www.ipcc.ch/) 2. NASA Earth Observatory (https://earthobservatory.nasa.gov/) 3. UNEP Publications (https://www.unep.org/)

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Environmental Chemistry
Course Code	ENV-5000
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To study the properties of air/water/soil pollutants, and familiarize with different methods to control air/water/soil pollution in the environment.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Classify air, water, and soil pollutants based on their sources, composition, and their environmental impacts	PSO 1
	CO 2. Apply appropriate techniques for sampling, measurement, and analysis of major air pollutants.	PSO 1

	CO 3. Evaluate types of water pollutants, and to monitor, control pollution, and implement water treatment strategies.		PSO 1	
	CO 4. Summarize solid waste management principles, methods of collection, segregation, disposal, and environmentally sustainable solutions.		PSO 1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Classification and properties of air pollutants, emission sources- natural and anthropogenic, photochemical smog and its effects on environment. Air pollution: sampling and measurement, ambient air, collection of gaseous air pollutants, collection of particulate pollutants-stack sampling, analysis of air pollutants-sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone, hydrocarbons and particulate matter.	**15**	CO1 CO2	K2, K4
Module 2:	Types of water pollutants: sewage and domestic wastes, industrial wastes, agriculture discharges, toxic wastes. Basic process of water treatment- primary treatment, pre-treatment, sedimentation, floatation secondary (biological) treatment, active sludge process, advance filteration technique, trickling filters, sludge treatment and disposal. Advanced waste water treatment- removal of suspended solids, removal of dissolved solids, nitrogen and phosphorous removal, advanced biological systems, chemical oxidation.	**15**	CO1 CO3	K2, K5
Module 3:	Sources of soil pollution: industrial wastes, domestic wastes, radioactive pollutants, pesticides and agricultural waste. Detrimental effects of soil pollutants-industrial wastes, domestic wastes, radioactive wastes and agricultural wastes to the environment. Solid waste management: sources and classification, public health aspects, methods of collection, disposal methods.	**15**	CO1 CO4	K2, K5
Pedagogy:	Lectures/ tutorials/ assignments			
References/ Readings:	1. Bakour, I., Isaure, M.-P., Barrouilhet, S., Goni-Urriza, M., & Monperrus, M. (2025). Mercury interaction with S-containing molecules: Implications for methylation and demethylation processes in sulfate-reducing bacteria. *Frontiers in Environmental Chemistry, 6*, Article 123456.			

	2. Chiras, D. D. (1994). *Environmental science* (4th ed.). Jones & Bartlett Publishers, Sudbury, MA, USA. 3. Clark, R. B. (1986). *Marine pollution*. Oxford Science Publications, Oxford, United Kingdom. 4. Hussain, S. (2024). Recent trends in chitosan-based hydrogels for water treatment applications: A bibliometric analysis. *International Journal of Environmental Analytical Chemistry*,1-23. 5. Kudesia, V. P. (1985). *Water pollution*. Pragati Prakashan, Meerut, India. 6. Lodge, J. P. (Ed.). (1994). *Methods of air sampling and analysis* (3rd ed.). CRC Press. Boca Raton, Florida, USA. 7. Manahan, S. E. (2017). *Environmental chemistry* (10th ed.). CRC Press. Boca Raton, FL, USA. 8. Seinfeld, J. H., & Pandis, S. N. (2006). *Atmospheric chemistry and physics: From air pollution to climate change* (2nd ed.). John Wiley & Sons. Hoboken, NJ, USA. 9. Stumm, W., & Morgan, J. J. (1996). *Aquatic chemistry: Chemical equilibria and rates in natural waters* (3rd ed.). John Wiley & Sons. Hoboken, NJ, USA. 10. Turekian, K. K. (2010). *Marine chemistry and geochemistry*. Academic Press, Cambridge, MA, USA.

Title of the Course	Environmental Chemistry Practical
Course Code	ENV-5001
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To understand the concentration of various pollutants in natural waters and their influence in biota.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Analyze the dissolved oxygen, chemical and biochemical oxygen demand data to assess the quality of coastal waters.	PSO 1, PSO 2
	CO 2. Estimate hydrogen sulphide levels in coastal waters and interpret the results to assess water quality.	PSO 1, PSO 2
	CO 3. Apply spectrophotometric method to determine phosphorus concentration in polluted water and evaluate its environmental impact	PSO 1, PSO 2
	CO 4. Perform fluoride estimation in drinking water, to understand the implications for public health	PSO 1, PSO 2

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Determination of chemical oxygen demand in coastal waters. 2. Determination of dissolved oxygen in coastal waters. 3. Determination of biochemical oxygen demand in coastal waters. 4. Estimation of hydrogen sulphide in coastal waters. 5. Estimation of phosphorus in polluted water. 6. Determination of fluoride in drinking water.	**30**	CO1 CO1 CO1 CO2 CO3 CO4	K4 K4 K4 K4 K5 K3
Pedagogy:	Demonstrations / lab experiments/ operation of different instruments.			
References/ Readings:	1. Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby, C., & Roberts, J. D. (1976). Chemical analysis. In S. B. Chapman (Ed.), *Methods in plant ecology* (Chap. 8). Blackwell Scientific Publications, Oxford, United Kingdom. 2. Ewing, G. W. (1981). *Instrumental methods of chemical analysis*. McGraw-Hill, New York, NY, USA. 3. Grasshoff, K., Ehrhardt, M., & Kremling, K. (1983). *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany. 4. Khopkar, S. M. (2008). *A laboratory manual for environmental chemistry*. I. K. International Publishing House, New Delhi, India. 5. Murphy, R. A. (2022). *Environmental chemistry in the lab* (1st ed.). CRC Press, Boca Raton, FL, USA. 6. Parsons, T. R., Maita, Y., & Lalli, C. M. (1984). *A manual of chemical and biological methods for seawater analysis*. Pergamon Press, Oxford, United Kingdom. 7. Rice, E. W., & Bridgewater, L. (2012). *Standard methods for the examination of water and wastewater analysis* (22nd ed.). American Public Health Association, Washington D.C, USA.			

Title of the Course	Environmental Biology and Ecology
Course Code	ENV-5002
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Develop advanced understanding of ecosystem dynamics and biodiversity. • Apply scientific methods in environmental assessment and conservation practices. • Analyze and address global environmental challenges through policy and management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply knowledge of ecological principles and biodiversity to assess ecosystem health and environmental issues.	PSO 1
	CO 2. Analyze and interpret data on biodiversity, pollution, and ecosystem functions using advanced ecological methods and tools.	PSO 1, PSO 2
	CO 3. Critically evaluate global environmental challenges and propose sustainable solutions using research and policy analysis.	PSO 1, PSO 6

	CO 4. Design and implement ecological restoration projects and assess their effectiveness in real-world environments.		PSO 1, PSO 6	
	CO 5. Demonstrate proficiency in conducting field-based environmental assessments, including biodiversity surveys and environmental impact assessments (EIA).		PSO 1	
	CO 6. Communicate complex environmental issues and research findings effectively through scientific reports, presentations, and policy briefs.		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module I:	***Fundamentals of Environmental Biology and Ecology***			
	Introduction to Environmental Science and Ecology	**15**	CO1	K3
	Physico-Chemical and Biological Factors Affecting the Environment		CO2	K4
	Concept and Principles of Ecosystems		CO1	K3
	Ecological Pyramids and Disruption of Food Chains		CO1	K3
	Ecological Succession		CO2	K4
	Ecosystem Classification: Terrestrial and Aquatic		CO1	K3
	Types of Major Biomes		CO1	K3
	Population Ecology Fundamentals		CO2	K4
	Community Ecology		CO2	K4
	Human Impact on Ecosystems and Biodiversity		CO3	K5
	Climate Regulation and the Role of Forests		CO3	K5
	Hydrology and Green Belt in Urban Environments		CO2	K4
	Aquatic Ecology: Species-Specific Interactions		CO1	K3
	Terrestrial and Aquatic Ecosystems: Ecological Functions		CO2	K4

	Global Environmental Issues: Climate Change and Biodiversity Loss		CO3	K5
Module II:	***Biodiversity and Conservation***			
	Concept of Biodiversity	**15**	CO1	K3
	Taxonomic, Genetic, and Phylogenetic Biodiversity		CO2	K4
	Measurement of Biodiversity		CO2	K4
	Western Ghats as Biodiversity Hotspots in India		CO1	K3
	National Parks and Sanctuaries in India		CO5	K3
	Biosphere Reserves and Marine Protected Areas		CO5	
	Keystone, Umbrella and flagship Species and Their Role in Ecosystems		CO1	K3
	IUCN Red List: Threatened and Endemic Species		CO3	K5
	Eco-Restoration Techniques		CO4	K6
	Sustainable Development and Biodiversity Conservation		CO3	K5
	Habitat Degradation and Fragmentation		CO3	K5
	Endangered Species and Conservation Efforts		CO3	K5
	Advanced Technologies in Conservation		CO2	K4
	International Conservation Policies and Treaties		CO3	K5
	Conservation and Sustainable Management of Marine Ecosystems		CO4	K6
Module III:	***Environmental Management and Policy***			
	Introduction to Environmental Management	**15**	CO3	K5
	Environmental Sustainability and Development		CO3	K5
	Environmental Ethics and Philosophy		CO3	K5
	Environmental Governance and Legal Frameworks		CO3	K5

	Pollution Control and Waste Management		CO2	K4
	Environmental Impact Assessment (EIA)		CO5	K6
	Ecological Restoration and Habitat Conservation		CO4	K6
	Climate Change Mitigation and Adaptation		CO3	K5
	Corporate Social Responsibility (CSR) and the Environment		CO3	K5
	Environmental Education and Advocacy		CO6	K1
	International Environmental Policy and Agreements		CO3	K5
	Biodiversity Conservation and Policy (Biodiversity Protection Act 1972, 2003)		CO3	K5
	Sustainable Resource Management		CO4	K6
	Environmental Risk Assessment and Disaster Management		CO5	K6
	Future Directions in Environmental Management		CO3	K5
Pedagogy:	Use of conventional, online and ICT methods. Lecture/ tutorials/ assignments, field-based learning, discussions, and project work			
References/ Readings:	1. Bhatt, S., Kohli, K., & Kothari, A. (2006). *Process documentation of the National Biodiversity Strategy and Action Plan-India*. Kalpavriksh Environmental Action Group. Pune, India. 2. Dey, S. (2004). *Bioresources and genepool conservation*. Pointer Publishers, New Delhi, India. 3. Odum, E. P. (2004) Kemp, D., & Parto, S. (2005). *Fundamentals of ecology* (5th ed.). Saunders Belmont, CA, USA. 4. Grimmett, R., Inskipp, C., & Inskipp, T. (2016). *Birds of the Indian Subcontinent: India, Pakistan, Sri Lanka, Nepal, Bhutan, Bangladesh and the Maldives*. Bloomsbury Publishing, London, United Kingdom. 5. Whitaker, R., Captain, A., & Ahmed, F. (2004). *Snakes of India*. Draco Books. Chennai, India. 6. Sawaiker, R. U. (2021). Conservation of biodiversity through scientifically validated and well-participated people's biodiversity registers (PBRs) in Goa, India. *Asian Journal of Conservation Biology,* 10(1), 159–161.			

Title of the Course	Environmental Biology and Ecology Practical
Course Code	ENV-5003
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	1. To equip students with practical skills for ecological assessment through field-based surveys, mapping, and data collection in both terrestrial and aquatic ecosystems. 2. To develop an understanding of biodiversity and its role in ecosystem functioning. 3. To provide hands-on experience in evaluating and mitigating environmental impacts through pollution monitoring, ecosystem health assessments, and the application of Environmental Impact Assessment (EIA) for local development projects.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate proficiency in field-based ecological data collection	PSO 1
	CO 2. Apply biodiversity indices for assessing ecosystem health and biodiversity	PSO 1
	CO 3. Analyze the ecological impact of urban green spaces on biodiversity and ecosystem services	PSO 1, PSO 4

	CO 4. Conduct environmental impact assessments (EIA) to evaluate ecosystem health and inform conservation strategies		PSO 1, PSO 6	
	CO 5. Implement ecological restoration techniques, including invasive species removal and native species reintroduction		PSO 1	
	CO 6. Evaluate conservation practices and biodiversity monitoring strategies in protected areas		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Field Survey Techniques: Mapping, and ecosystem data collection in terrestrial and aquatic ecosystems for ecological assessment.	**30**	CO1	K2, K3
	2. Sampling for organisms: Transect, point count, quadrat.		CO1	K2, K3
	3. Biodiversity Assessment in Terrestrial & Aquatic Ecosystems: Identification and documentation of biodiversity using biodiversity indices to evaluate ecosystem health.		CO2	K3
	4. Pollution Monitoring in Urban Green Spaces: Conducting field-based evaluation of urban green spaces, focusing on biodiversity, ecosystem services, and their role in enhancing urban environmental quality.		CO3	K3, K4
	5. Ecosystem Health Assessment & EIA Field Assessment: Evaluating ecosystem health through field-based assessments and conducting Environmental Impact Assessment (EIA) for local development projects.		CO4	K3, K4
	6. Restoration Ecology Techniques: Practical exposure to ecological restoration through invasive species removal, habitat restoration, and native species reintroduction.		CO5	K3
	7. Field Trip to Protected Area: Observation and evaluation of conservation practices, wildlife management, and biodiversity monitoring in protected areas.		CO6	K5
Pedagogy:	Hands-on practicals/ demonstrations/ field visit			

References/ Readings:	1. Bhatt, S., Kohli, K., & Kothari, A. (2006). *Process documentation of the National Biodiversity Strategy and Action Plan-India*. Kalpavriksh Environmental Action Group. Pune, Maharashtra, India. 2. Dey, S. (2004). *Bioresources and genepool conservation*. Daya Books. New Delhi, India. 3. Grimmett, R., Inskipp, C., & Inskipp, T. (2016). *Birds of the Indian Subcontinent: India, Pakistan, Sri Lanka, Nepal, Bhutan, Bangladesh and the Maldives*. Bloomsbury Publishing. London, United Kingdom. 4. Kemp, D., & Parto, S. (2005). *The International Handbook of Environmental and Resource Economics*. Edward Elgar Publishing. Cheltenham, United Kingdom. 5. Krebs, C. J. (2014). *Ecological methodology* (3rd ed.). Pearson. Boston, MA, USA. 6. Odum, E. P. (2004). *Fundamentals of ecology* (5th ed.). Saunders. Belmont, California, USA. 7. Whitaker, R., Captain, A., & Ahmed, F. (2004). *Snakes of India*. Draco Books. Chennai, India. 8. Sawaiker, R. U. (2021). Conservation of biodiversity through scientifically validated and well-participated people's biodiversity registers (PBRs) in Goa, India. *Asian Journal of Conservation Biology*, 10(1), 159–161.

Title of the Course	Environmental Geology and Soil Science
Course Code	ENV-5004
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide knowledge on the interaction of humans with the geological environment, mechanism behind natural hazards and different geological resources and their management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain principles of geological processes and describe the impact of natural hazards	PSO 1, PSO 6
	CO 2. Classify different rock types and minerals based on physical properties.	PSO 1
	CO 3. Evaluate various mineral exploration and mining techniques and environmental impact.	PSO 1, PSO 6
	CO 4. Analyse soil forming processes and classify soil types of India.	PSO 1

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction and scope of environmental geology. Geological time scale, internal structure and composition of the earth. Concept of plate tectonics – types of lithospheric plates, continental drift and sea floor spreading. Catastrophic natural hazards – volcanoes, earthquake, tsunami. Coastal erosion – protection and restoration.	**15**	CO1	K2
Module 2:	Important rock forming minerals. Composition, physical properties and distribution of important economic mineral deposits. Rock cycle – classification, properties and distribution of rocks. Minerals and human use. Mineral exploration techniques – opencast mining, underground mining. Mine gases and mine diseases, environmental impact and mitigation.	**15**	CO2, CO3	K2, K5
Module 3:	Introduction to soil science - Soil forming processes – chemical, physical and biological weathering, development of horizons and soil profile. Physical and chemical properties of soil, soil mineralogy. Soil classifications and soil types of India. Soil as a resource. Soil erosion, strategies to reduce soil erosion. Soil contamination and desertification.	**15**	CO4	K4, K2
Pedagogy:	Lectures, case studies, discussions and assignments			
References/ Readings:	1. Keller, E. A. (2012). *Introduction to environmental geology* (5th ed.). Prentice Hall, New Jersey, USA. 2. Montgomery, C. W. (2006). *Environmental geology* (p. 540). McGraw-Hill. Boston, MA, USA. 3. Pipkin, B. W., Trent, D. D., Hazlett, R., & Bierman, P. (2013). *Geology and the environment*. Cengage Learning. Belmont, CA, USA. 4. Valdiya, K. S. (1987). *Environmental geology: Indian context*. Tata McGraw-Hill Publishing Company. New Delhi, India.			

Title of the Course	Environmental Geology and Soil Science Practical
Course Code	ENV-5005
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To develop ability to identify economic minerals and rocks and demonstrate basic methods for analysis of soil samples, its characteristics and recognition.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe common economic minerals and igneous, sedimentary and metamorphic rocks.	PSO 1
	CO 2. Prepare maps of plate boundaries, volcanoes and earthquakes.	PSO 1
	CO 3. Prepare soil distribution maps of Goa using NBSS data source.	PSO 1
	CO 4. Measure grain size in soil samples.	PSO 1

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Megascopic study of common economic minerals.	30	CO1	K2
	2. Megascopic study of common Igneous, sedimentary and metamorphic rocks.		CO1	K2
	3. Marking of plate boundaries, volcanoes and earthquakes on world map and preparation of informative report.		CO2	K3
	4. Preparation of soil distribution maps of Goa using NBSS data source.		CO3	K3
	5. Collection of soil sample and grain size distribution analysis.		CO4	K5
Pedagogy:	Hands-on practical / demonstrations, discussions.			
References/ Readings:	1. Best, M. G. (2002). *Igneous and metamorphic petrology*. John Wiley & Sons. Hoboken, NJ, USA. 2. Condie, K. C. (1989). *Plate tectonics and crustal evolution* (3rd ed.). Pergamon Press, Oxford, UK. 3. Deer, W. A., Howie, R. A., & Zussman, J. (2013). *An introduction to the rock-forming minerals*. Mineralogical Society of Great Britain and Ireland. London, United Kingdom. 4. Lindholm, R. (2012). *A practical approach to sedimentology*. Springer Science & Business Media. London, United Kingdom.			

Title of the Course	Atmospheric Science and Climate Change
Course Code	ENV-5006
Number of Credits	03
Theory/ Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide a basic understanding of atmospheric science and climate change	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe and explain the basic processes in the atmosphere, gas laws, solar and infra-red radiation and thermodynamics.	PSO 1
	CO 2. Discuss and explain water vapour, and precipitation processes.	PSO 1
	CO 3. Describe and explain atmospheric forces, wind, fronts and air masses and thunder storms.	PSO 1
	CO 4. Classify basic clouds types	PSO 1
	CO 5. Illustrate and explain circulation in the atmosphere, tropical cyclones and related aspects	PSO 1, PSO 6

	CO 6. Evaluate aspects of Climate Change		PSO 1, PSO 6	
Content:		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Atmospheric Basics: Overview of the Earth's Atmosphere; Equation of State; Ideal Gas Law; Hydrostatic Balance; Layers of the Atmosphere; The Difference of Weather and Climate. Solar and Infrared Radiation: Radiation; Blackbody Laws; Application to the Earth-Sun System Thermodynamics: Introduction; Energy Transfer; Lapse Rates; Potential Temperature; Heat Budget at the Earth's Surface	**15**	CO1	K2
Module 2:	Water Vapour: Humidity Variables Atmospheric Stability: Introduction; Atmospheric Stability and Lapse Rates Clouds: Introduction and Formation of Clouds; Cloud Naming Convention Precipitation Processes: Cloud Droplets; Collision-Coalescence Process; Ice Phase Process; Types of Precipitation	**15**	CO2 CO4	K2 K4
Module 3:	Atmospheric Forces and Wind: Main Forces; Force Balances General Circulation: Three-Cell Model; Monsoons; El Niño-Southern Oscillation; Madden-Julian Oscillation Fronts and Air-masses: Air Masses; Surface Fronts Thunderstorm Fundamentals: Thunderstorms Tropical Cyclones: Structure; Evolution Climate Change: Causes; Effects; Examples; Mitigation; Intergovernmental Panel on Climate Change (IPCC) Reports	**15**	CO3 CO5 CO6	K2 K3 K5
Pedagogy:	Lectures/ Tutorials/ Assignments			
References/ Readings:	1. Ahrens, C. D., Jackson, P. L., & Jackson, C. E. J. (2012). *Meteorology today: An introduction to weather, climate, and the environment* (1st Canadian ed.). Nelson Education. Ontario, Canada. 2. Berdin, V., Dobrolyubova, Y., Gracheva, E., Konstantinov, P., Ryzhova, N., Smirnova, E., & Zamolodchikov, D.			

	(2018). *Climate box: An interactive learning toolkit on climate change*. United Nations Development Programme. https://www.undp.org/sites/g/files/zskgke326/files/migration/eurasia/Climatebox_textbook_EN.pdfIstanbul,Turkey. 3. Houghton, J. T. (2002). *The physics of atmospheres* (3rd ed.). Cambridge University Press, Cambridge, United Kingdom. 4. Intergovernmental Panel on Climate Change. (2021). *Climate change 2021: The physical science basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom. 5. Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom. 6. Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change*. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom. 7. Nugent, A., DeCou, D., Russell, S., & Karamperidou, C. (2019). *Atmospheric processes and phenomena*. University of Hawai‘i at Mānoa, Hawaii, USA. 8. Schmittner, A. (2019). *Introduction to climate change*. Oregon State University, Oregon, USA. 9. Stull, R. (2017). *Practical meteorology: An algebra-based survey of atmospheric science*. University of British Columbia, Vancouver, Canada. 10. Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric science: An introductory survey* (2nd ed.). Elsevier Academic Press, Amsterdam, Netherlands.
Web Resources:	1. http://pressbooks-dev.oer.hawaii.edu/atmo/ 2. https://www.eoas.ubc.ca/books/Practical_Meteorology/ 3. https://www.undp.org/sites/g/files/zskgke326/files/migration/eurasia/Climatebox_textbook_EN.pdf 4. https://open.oregonstate.education/climatechange/ 5. https://www.ipcc.ch/

Title of the Course	Atmospheric Science and Climate Change Practical
Course Code	ENV-5007
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To provide some practical skills in analyses of some datasets, and also measurement of some variables, for obtaining a better understanding of the atmosphere and Climate Change.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Analyse temperatures, extent of sea-ice and radio-sonde data		PSO 1, PSO 6	
	CO 2. Deduce links between sea surface temperature and rainfall		PSO 1, PSO 5, PSO 6	
	CO 3. Measure atmospheric temperature and humidity		PSO 1	
	CO 4. Distinguish between basic cloud types		PSO 1	
	CO 5. Estimate cloud cover		PSO 1	
Content:		**No. of**	**Mapped to**	**Cognitive**

		hours	CO	Level
Module 1:	1. Analyses of Temperatures and its trends.	**30**	CO1	K4
	2. Linkages between Sea Surface Temperature and Rainfall.		CO2	K4
	3. Measurement of Atmospheric Temperature and Humidity.		CO3	K5
	4. Analysis of the Extent of Sea-Ice.		CO1	K4
	5. Analysis of Radiosonde Data		CO1	K4
	6. Observations of Cloud Cover and Type		CO4, CO5	K4, K5
Pedagogy:	Tutorials/assignments/practicals/ field-study			
References/ Readings:	1. Karnauskas, K. (2020). *Physical oceanography and climate*. Cambridge University Press, Cambridge, United Kingdom. 2. Stocker, T. F., Clarke, G. K. C., Le Treut, H., Lindzen, R. S., Meleshko, V. P., Mugara, R. K., Palmer, T. N., et al. (2001). Physical climate processes and feedbacks. In J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, & C. A. Johnson (Eds.), *Climate change 2001: The scientific basis* (pp. 417–470). Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, United Kingdom. 3. World Meteorological Organization. (2021). *Guide to instruments and methods of observation* (WMO-No. 8) (2018 ed.). https://community.wmo.int/en/activity-areas/imop/wmo-no_8 Geneva, Switzerland. 4. Intergovernmental Panel on Climate Change. (2019). *Special report on the ocean and cryosphere in a changing climate*. Cambridge, United Kingdom. 5. Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric science: An introductory survey* (2nd ed.). Elsevier Academic Press, Amsterdam, Netherlands. 6. World Meteorological Organization. (2020). *Cloud identification guide*. World Meteorological Organization, Geneva, Switzerland.			
Web Resources:	1. https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-07.pdf 2. https://community.wmo.int/en/activity-areas/imop/wmo-no_8 3. https://www.ipcc.ch/srocc/			

	4. https://cloudatlas.wmo.int/en/cloud-identification-guide.html

Discipline Specific Elective Courses

Title of the Course	Coastal Habitats and Processes
Course Code	ENV-5201
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce to the marine environment with special emphasis on coastal habitats and processes. • To elucidate impact of anthropogenic effects on water quality degradation and fish exploitation in coastal habitats.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the structure and function of marine ecosystems, productivity, nutrient dynamics, and marine food web processes.	PSO 1
	CO 2. Explain the dynamics of marine communities and resources, including ecological niches, population processes, migrations, larval ecology, and oceanographic features.	PSO 1
	CO 3. Describe key coastal habitats, focusing on species, adaptations, productivity, energy flow, and the ecological role of blue carbon.	PSO 1, PSO 6

	CO 4. Analyze human impacts on coastal ecosystems and evaluate strategies for sustainable fishing, algal bloom control, and coastal resource management.		PSO 1, PSO 4, PSO 6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Marine Environment – Divisions of marine ecosystem, coastal and open ocean habitats, productivity, nutrient dynamics, MLD, and associated processes. Marine food webs, standing crop and carrying capacity. Living and non-living resources, marine communities, ecological niche, pyramid, population processes, upwelling, sub-surface chlorophyll maxima (SCM) and migrations (diurnal and ontogenic), larval ecology and bi-phased life cycle of benthic communities. Oxygen Minimum Zone (OMZ).	**15**	CO1, CO2	K2
Module 2:	Coastal habitats - inter-tidal ecosystem - rocky shore - zonation pattern - physical and biological factors, sandy shores and protected sand flats - physical and biological factors, faunal composition and adaptations. Salt marsh ecosystem – species composition, distribution, nutrient dynamics, primary productivity and ecological processes and fate of salt marsh plant; Mangrove ecosystem species composition, distribution, adaptations, primary productivity, heterotrophic production, secondary communities and energy flow. Blue carbon, key functions, threats and conservation.	**15**	CO3	K2
Module 3:	Human impact and coastal zone – primary productivity, Biological pump, Industrial, agriculture, sewage and other effluents, effect on water quality and marine life. Blooming events - bloom initiation, formation, propagation, decomposition, prevention and control - Chemical, biological, flocculants, role of zooplankton, viruses, parasites, bacteria. Potential Fishing Zones (PFZ), overexploitation and habitat destruction, Sediment dredging, Responsible fishing and sustainable management.	**15**	CO4	K4
Pedagogy:	Lectures/ tutorials/ assignments/ self-study			
References/ Readings:	1. Nybakken, J. W., & Bertness, M. D. (2005). *Marine biology: An ecological approach* (6th ed.). Pearson/Benjamin Cummings. San Francisco, CA, USA. 2. Levinton, J. S. (1982). *Marine ecology*. Prentice-Hall. Englewood Cliffs, NJ, USA.			

	3. Mann, K. H. (2000). *Ecology of coastal waters: With implications for management* (2nd ed.). Blackwell Science, Oxford, United Kingdom. 4. Parsons, T. R., Takahashi, M., & Habgrave, B. (1984). *Biological oceanographic processes* (3rd ed.). Pergamon Press, Oxford, United Kingdom. 5. Valiela, E. (1995). *Marine ecological processes*. Springer Verlag, New York, USA.

Title of the Course	Coastal Habitats and Processes Practical
Course Code	ENV-5202
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To identify commonly occurring marine organisms using morphological features.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply standard methods to analyze and preserve biological communities from seawater and sediment.	PSO 1, PSO 5, PSO 6
	CO 2. Identify key mangrove species and describe their life cycles and biological characteristics.	PSO 1
	CO 3. Identify hard corals, teleost fishes, and brachyuran crabs using morphological features and explain their biological roles.	PSO 1
	CO 4. Distinguish prawns and shrimps based on external morphology and sex characteristics,	PSO 1

	and interpret their biological significance.			
Module 1:		**No of hours**	**Mapped to CO**	**Cognitive Level**
	1. Analysis of biological communities (water and sediment), their preservation and storage techniques using standard methods.	**30**	CO1	K3
	2. Identification of mangroves, their lifecycle and few biological characteristics.		CO2	K2
	3. Identification of hard corals and a few biological characteristics.		CO3	K2
	4. Identification of few commonly occurring teleosts (ray-finned fishes) and their biological characteristics.		CO3	K2
	5. Identification of brachyuran crabs using morphology and gonopod characteristics, sex determination and their biological importance.		CO3	K5
	6. Identification of prawns and shrimps using external characteristics, sex determination biological aspects.		CO4	K5
Pedagogy:	Demonstrations/ practical/ identification of marine flora and fauna/ field studies.			
References/ Readings:	1. Intergovernmental Oceanographic Commission. (1994). *Protocols for the Joint Global Ocean Flux Study (JGOFS) core measurements*. UNESCO-IOC. https://doi.org/10.25607/OBP-1409 Paris, France. 2. Untawale, A. G. (1985). *Mangroves of India: Present status and multiple use practices*. UNDP/UNESCO Regional Mangrove Project. Paris, France. 3. Dhargalkar, V. K., D'Souza, R., Kavlekar, D. P., & Untawale, A. G. (2014). *Mangroves of Goa*. Forest Department, Government of Goa, & Mangroves Society of India, Goa, India. 4. Hogarth, P. J. (2015). *The biology of mangroves and seagrasses*. Oxford University Press, Oxford, United Kingdom. 5. Venkataraman, K., Satyanarayana, Ch., Alfred, J. R. B., & Wolstenholme, J. (2003). *Handbook on hard corals of India*. Zoological Survey of India, Kolkata, India. 6. Carpenter, K. E., & Niem, V. H. (1999). *FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific (Vol. 4, Bony Fishes Part 2, Mugilidae to Carangidae)*. Food and Agricultural Organization, Rome, Italy.			

	7. Carpenter, K. E., & Niem, V. H. (2001). *FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific (Vol. 5, Bony Fishes Part 3, Menidae to Pomacentridae)*. Food and Agricultural Organization, Rome, Italy. 8. Carpenter, K. E., & Niem, V. H. (1988). *FAO species identification guide for fishery purposes: The living marine resources of the Western Central Pacific (Vol. 2, Cephalopods, crustaceans, holothurians, and sharks)*. Food and Agricultural Organization, Rome, Italy.

Title of the Course	Mangrove Ecosystem, Biodiversity and Conservation
Course Code	ENV-5203
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce the students to the dynamic mangrove ecosystem, its composition – abiotic and biotic, benefits, threats and need for conservation.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Gain knowledge about mangrove ecosystem, its floral and faunal biodiversity	PSO1
	CO 2. Imprint the importance of mangroves in maintaining the global climate and balance in the nutritional as well as biogeochemical cycles.	PSO1
	CO 3. Study the flora and fauna of the mangrove ecosystem	PSO1, PSO4
	CO 4. Highlight the need to conserve and protect the mangroves	PSO3, PSO4, PSO5, PSO6

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	*Structure and function of mangrove ecosystem:* Mangroves; global distribution; economic importance; current status; threats; ecology and environment; relation with other ecosystems; uses of mangroves; physical mangrove environment; forest types: overwashed, fringe, dwarf, riverine, basin, hammock; true mangroves: red, white, green, black; mangrove associates; adaptations in mangroves; patterns and processes in mangrove ecosystem; environmental factors; climate and habitats. Biodiversity in mangrove ecosystem: flora and fauna.	**15**	CO 1	K1, K2
Module 2:	*Ecological importance of mangrove ecosystem and the impact of anthropogenic activities:* Functional aspects: biomass, productivity, litter and its decomposition, carbon sink and organic carbon productivity; nitrogen and sulfur cycling; nutrient status; nurseries; biofilters for toxic pollutants; breeding grounds – fish, birds; mitigation of climate change; coastal defence mechanism; Indigenous people of mangroves: livelihood dependency; Case study mangroves of Sunderban and Goa. Anthropogenic destruction: deforestation; landfills; land reclamation; waste disposal sites; pollution: water quality and persistent chemicals; loss of mangrove biodiversity.	**15**	CO 2	K2, K4
Module 3:	*Restoration and conservation:* Restoration and afforestation projects; ecosystem based management; protected areas; restoration tools; monitoring methods: remote sensing and GIS; awareness programmes; training programmes; community based management; role of institutions; NGOs; national and global conservation strategies and policies; conservation and mangrove protection laws; economic valuation (cost benefit analysis); international agreements – Ramsar convention; case study – mangroves of Goa.	**15**	CO 3	K2, K3, K4
Pedagogy:	Lectures/ case studies/ tutorials/ videos/ assignments/ self-study/ visits to mangrove conservation sites			

References/ Readings:	1. FAO. (2007). *The world's mangroves: 1980–2005*. Food and Agriculture Organization, Rome, Italy. 2. First International Training Course on Mangrove Ecosystems in the Western Indian Ocean Region. (2013, December 2–9). *Mangrove ecosystems in the Western Indian Ocean region*. UNU-INWEH-UNESCO, Ontario, Canada. 3. Kathiresan, K., & Ajmal Khan, S. (2005). *UNU-INWEH-UNESCO international training course on coastal biodiversity in mangrove ecosystem—Course manual* (p. 410). Annamalai University, Tamil Nadu, India. 4. Nagelkerken, I., Blaber, S. J. M., Bouillon, S., et al. (2008). The habitat function of mangroves for terrestrial and marine fauna: A review. *Aquatic Botany, 89*, 155–185. 5. Nanjo, K., Kohno, H., Nakamura, Y., Horinouchi, M., & Sano, M. (2014). Effects of mangrove structure on fish distribution patterns and predation risks. *Journal of Experimental Marine Biology and Ecology, 461*, 216–225. 6. Sandilyan, S., & Kathiresan, K. (2012). Mangrove conservation: A global perspective. *Biodiversity Conservation, 21*, 3523–3542. 7. Singh, V. P., & Odaki, K. (2004). *Mangrove ecosystem: Structure and function*. Scientific Publishers, Jodhpur, India. 8. Shinnaka, T., Sano, M., Ikejima, K., Tongnunui, P., Horinouchi, M., & Kurokura, H. (2007). Effects of mangrove deforestation on fish assemblage at Pak Phanang Bay, Southern Thailand. *Fisheries Science, 73*, 862–870.
Web Resources:	1. www.lifegate.com/sundarbans-beekeeping 2. https://youtu.be/svvYyljtcTk 3. https://www.youtube.com/watch?v=0ehUoK7xyvg 4. https://www.youtube.com/watch?v=6VHBJdTGH9k&t=7s 5. https://www.facebook.com/godrejlawkimmotors/videos/godrej-mangroves-world-nature-conservation-day-2020/305862404099765/ 6. https://www.youtube.com/watch?v=BFORURgz38I 7. https://www.youtube.com/watch?v=cwTZhyA57mA 8. https://www.youtube.com/watch?v=NOA-Al0RLKk 9. https://www.youtube.com/watch?v=0bsnP1B6-nE 10. https://www.youtube.com/watch?v=BzU0sJ6eZ7I 11. https://www.youtube.com/watch?v=s4br-wCS5ds

	12. https://www.youtube.com/watch?v=hOKjrN2yRts 13. https://www.youtube.com/watch?v=mzn0z30nyJM 14. https://www.youtube.com/watch?v=t9qlVvEqP5U 15. https://www.youtube.com/watch?v=aI1u0YZWT-w 16. https://www.youtube.com/watch?v=nbN6zWUnm18 17. https://www.youtube.com/watch?v=YzzwGS0BijY&t=11s 18. https://www.littledayout.com/mangroves-and-marshlands-in-singapore-to-visit-on-your-next-nature-walk/ 19. https://www.youtube.com/watch?v=csq5XYCtZ9g 20. https://www.youtube.com/watch?v=NOA-Al0RLKk 21. https://edition.cnn.com/2019/07/15/middleeast/abu-dhabi-mangroves-scn-intl/index.html

Title of the Course	Mangrove Ecosystem, Biodiversity and Conservation Practical
Course Code	ENV-5204
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce the students to practical knowledge of mangrove ecosystem and its biodiversity studies	
Course Outcomes:		**Mapped to PSO**
	CO 1. Acquaint with types and species of mangroves in the state	PSO 1
	CO 2. Analyze physico-chemical parameters and their correlation with mangrove speciation	PSO 2
	CO 3. Evaluate the threats to mangroves	PSO 4, PSO 6
	CO 4. Create herbarium for preservation of mangroves	PSO 1, PSO 6

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1	1. Field visit to evaluate current status of mangrove cover in Goa.	**30**	CO1, CO2	K1, K2
	2. Mangrove flora and associated fauna found in Goa.		CO1, CO2	K2, K4
	3. Physico-chemical parameters of mangrove ecosystem: pH, salinity, temperature, BOD, nutrients.		CO2	K4, K5
	4. Impact of anthropogenic activity on mangrove ecosystem.		CO3	K2, K4, K5
	5. Preparation of herbarium.		CO4	K1-K5
Pedagogy:	Site visits, field work, laboratory experiments			
References/ Readings:	1. Goa Forest Department. (n.d.). *Threat to mangrove ecosystem*. In *Mangroves of Goa* (Chap. 6, pp. 79–83). Goa Forest Department, Goa, India. 2. Kothari, M. J., & Rao, K. M. (2002). *Mangroves of Goa*. In N. P. Singh & P. S. N. Rao (Eds.), Botanical Survey of India, Kolkata, India. 3. Kathiresan, K., & Ajmal Khan, S. (2005). *UNU-INWEH-UNESCO international training course on coastal biodiversity in mangrove ecosystem—Course manual* (p. 410). Annamalai University, Tamil Nadu, India. 4. Pawar, G. M., & Salgaokar, B. B. (2023). *The biodiversity and ecology of fragile ecosystems of Goa: The mangroves and the saltpans*. Project report. Goa Forest Department, Goa, India.			

Title of the Course	Remote Sensing Techniques and GIS
Course Code	ENV-5205
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	This course provides a foundational understanding of remote sensing principles, technologies, and applications, with a focus on data acquisition, sensor types, and practical uses in environmental and resource management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Define the basic concepts and components of remote sensing.	PSO 5
	CO 2. Understand the principles of EMR and its interaction with Earth and the atmosphere	PSO 5
	CO 3. Identify types of remote sensing platforms, sensors, and resolutions.	PSO 5
	CO 4. Explain the fundamentals, components, and applications of GIS	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to Remote Sensing: Definition, Scope, and Historical Evolution. Principles of Remote Sensing and Electromagnetic Radiation. Components of Remote Sensing. Transmission of Electromagnetic Radiation and its Interaction with Earth's Surface. Propagation of Reflected/Emitted Energy through Atmosphere.	**15**	CO 1, CO 2	K1, K2
Module 2:	Types of Remote Sensing Platforms. Types of Sensors. Concepts of Spatial, Spectral, Temporal, and Radiometric Resolution. Data Acquisition in Remote Sensing. Applications of Remote Sensing. Resources and limitations of Remote Sensing. In-situ and Remote Sensor Technologies and UAV Applications.	**15**	CO 3	K2, K3
Module 3:	Introduction to GIS: Definitions, Components, History and Evolution, Need and Scope; Interdisciplinary Relations, Application Areas, Current Issues, Trends and Future. GIS software packages: proprietary & open source. Introduction to GIS software framework. Data types: spatial data, non-spatial data; data structures and data models (Raster & Vector); ESRI Shapefile.	**15**	CO 4	K2
Pedagogy:	Use of Conventional, Online and ICT Methods. Lecture / Tutorials / Assignments			
Texts:	1. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing.* Guilford Press. 2. Chuvieco, E. (2016). *Fundamentals of Satellite Remote Sensing.* CRC Press. 3. Jensen, J. R. (2015). *Remote Sensing of the Environment: An Earth Resource Perspective.* Pearson, Boston, MA, USA. 4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2014). *Remote Sensing and Image Interpretation.* Wiley, Hoboken, NJ, USA. 5. Mobley, C. D. (1994). *Light and Water: Radiative Transfer in Natural Waters.* Academic Press, San Diego, CA, USA. 6. Richards, J. A. (2022). *Remote Sensing Digital Image Analysis.* Springer, Cham, Switzerland.			
References/ Readings:	1. Goodchild, M. F. (2009). Geographic information systems and science: Today and tomorrow. *Annals of GIS*, *15*(1), 3–9. 2. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). GIS and science: On the influence of			

	geography and geographic information science. *Geographical Analysis*, *37*(1), 1–8. 3. Mulla, D. J. (2013). Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. *Biosystems Engineering*, *114*(4), 358–371. 4. Pinter Jr., P. J., Hatfield, J. L., Schepers, J. S., Barnes, E. M., Moran, M. S., Daughtry, C. S. T., & Upchurch, D. R. (2003). Remote sensing for crop management. *Photogrammetric Engineering & Remote Sensing*, *69*(6), 647–664. 5. Rogan, J., & Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*, *61*(4), 301–325.
Web Resources:	1. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 2. IOCCG Reports on Ocean Colour Remote Sensing (https://ioccg.org/what-we-do/ioccg-publications/ioccg-reports/). 3. ISRO's Remote Sensing Handbooks (https://www.isro.gov.in/Miscellaneous.html). 4. LearnOSM. (n.d.). Beginner's Guide to OpenStreetMap (OSM) https://learnosm.org/en/beginner/ 5. NASA and ESA Satellite Data Portals (https://www.earthdata.nasa.gov/) 6. QGIS Documentation – Introduction to GIS Concepts (https://docs.qgis.org/latest/en/docs/gentle_gis_introduction/) 7. VEDAS (Visualisation of Earth observation Data and Archival System) https://vedas.sac.gov.in

Title of the Course	Remote Sensing Techniques and GIS Practical
Course Code	ENV-5206
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course provides hands-on experience in Geographic Information Systems (GIS) and remote sensing, emphasizing practical skills in spatial data analysis and visualization. Students will learn core techniques such as georeferencing, vector and raster data creation, error identification, topology building, and data conversion between formats. The course also introduces remote sensing concepts, including satellite image processing and interpretation, enabling students to extract and analyze geospatial information for diverse real-world applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand satellite data and its sources for remote sensing analysis	PSO 5
	CO 2. Evaluate and integrate remote sensing data for analysis and interpretation	PSO 5
	CO 3. Apply geospatial tools for data handling and visualization	PSO 5
	CO 4. Apply data conversion and mapping techniques in digital cartography	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Familiarisation with Panoply/QGIS/ERDAS/ArcGIS/Python/ MATLAB.	**30**	CO1	K1
	2. Familiarity with remote sensors, their data sources, and portals.		CO1	K1, K2
	3. Layer Stacking of Multispectral Imagery.		CO2	K2, K3
	4. Creating a subset of the image		CO2, CO3	K2, K3
	5. Band Combination and Colour Composites.		CO2, CO3	K2, K3
	6. Georeferencing, Vector data Creation, Working with Attributes.		CO2, CO3	K2, K3
	7. Conversion of existing data (Rasterise / vectorise).		CO2, CO3	K2, K3
	8. Digital Cartography: Layout Generation, Using Multiple Data Frames.		CO4	K3
Pedagogy:	Use of Conventional, Online and ICT Methods. Hands-on Practical			
Texts:	1. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing.* Guilford Press. 2. Chuvieco, E. (2016). *Fundamentals of Satellite Remote Sensing.* CRC Press. 3. Jensen, J. R. (2015). *Remote Sensing of the Environment: An Earth Resource Perspective.* Pearson, Boston, MA, USA. 4. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2014). *Remote Sensing and Image Interpretation.* Wiley, Hoboken, NJ, USA. 5. Mobley, C. D. (1994). *Light and Water: Radiative Transfer in Natural Waters.* Academic Press, San Diego, CA, USA. 6. Richards, J. A. (2022). *Remote Sensing Digital Image Analysis.* Springer, Cham, Switzerland.			
References/ Readings:	1. Goodchild, M. F. (2009). Geographic information systems and science: Today and tomorrow. *Annals of GIS, 15*(1), 3–9. 2. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). GIS and science: On the influence of geography and geographic information science. *Geographical Analysis, 37*(1), 1–8. 3. Mulla, D. J. (2013). Twenty-five years of remote sensing in precision agriculture: Key advances and remaining			

	knowledge gaps. *Biosystems Engineering*, *114*(4), 358–371. 4. Pinter, Jr., P. J., Hatfield, J. L., Schepers, J. S., Barnes, E. M., Moran, M. S., Daughtry, C. S. T., & Upchurch, D. R. (2003). Remote sensing for crop management. *Photogrammetric Engineering & Remote Sensing*, *69*(6), 647–664. 5. Rogan, J., & Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*, *61*(4), 301–325.
Web Resources:	1. Indian Space Research Organisation. (n.d.). Space Applications Centre: Earth observation, atmospheric studies, and remote sensing programs. https://www.sac.gov.in 2. IOCCG Reports on Ocean Colour Remote Sensing (https://ioccg.org/what-we-do/ioccg-publications/ioccg-reports/). 3. ISRO's Remote Sensing Handbooks (https://www.isro.gov.in/Miscellaneous.html). 4. LearnOSM. (n.d.). Beginner's Guide to OpenStreetMap (OSM) https://learnosm.org/en/beginner/ 5. NASA and ESA Satellite Data Portals (https://www.earthdata.nasa.gov/) 6. QGIS Documentation – Introduction to GIS Concepts https://docs.qgis.org/latest/en/docs/gentle_gis_introduction/ 7. VEDAS (Visualisation of Earth observation Data and Archival System) https://vedas.sac.gov.in

SEMESTER II

Discipline Specific Core Courses

Title of the Course	Analytical Techniques
Course Code	ENV-5008
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic knowledge of chemistry and biology.	
Course Objectives:	• Understand various instrumental methods used for environmental monitoring. • Understand the principles, and working of the various basic and advanced instruments used in environmental analysis.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the use of various analytical methods in environmental analysis.	PSO 1, PSO 2
	CO 2. Describe different types of microscopy, radioisotopes.	PSO 1, PSO 2

	CO 3. Explain the use of spectrometric assays in environmental analysis.		PSO 1, PSO 2	
	CO 4. Apply knowledge of environmental analysis of samples using the principles of chromatography, centrifugation and electrophoresis.		PSO 1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Chromatographic techniques: GC, HPLC, Ion-exchange, affinity and molecular exclusion; Centrifugation: Density gradient centrifugation, Ultracentrifugation; Spectrophotometry: Atomic Absorption Spectrophotometry (AAS), AES, UV-Visible, fluorimetry Spectroscopy: Fourier transformation infra-red spectroscopy (FTIR), NMR, IRMS, ICP MS, MALDI-TOF, Circular dichroism, Optical rotatory dispersion.	**15**	CO1, CO3, CO4	K3
Module 2:	Microscopy: Epifluorescence, SEM, TEM, Confocal microscopy; Radio-isotope and tracer techniques: Radio-activity counters, Autoradiography, Radiorespirometry. Sorting: Flow cytometry, Fluorescence activated cell sorter (FACS), Biosafety: Biosafety levels of laboratories, Biohazards and Biosafety cabinets.	**15**	CO1, CO2	K2
Module 3:	Electrophoretic techniques: PAGE, IEF, PFGE, DGGE, TGGE. X-ray diffraction: Energy Dispersive X-Ray Fluorescence, Wavelength Dispersive X-Ray Fluorescence. CNS analyser, Oxygen analyser, Particle size analyser, TOC analyser, Turbidimetry, Nephelometry.	**15**	CO1, CO3	K3
Pedagogy:	Lectures/ tutorials/ assignments/ self-study/ Videos			
References/ Readings:	1. Cooper, T. G. (2011). *The tools of biochemistry* (1st ed.). Wiley India Pvt. Ltd., New Delhi, India. 2. Ewing, G. W. (1995). *Instrumental methods of chemical analysis* (5th ed.). McGraw-Hill, New York, USA. 3. Goswami, C., Paintal, A., & Narain, R. (2011). *Handbook of bioinstrumentation*. Wisdom Press, New Delhi, India.			

	4. Jayaraman, J. (2011). *Laboratory manual in biochemistry*. New Age International Publishers, New Delhi, India. 5. Parakhia, M. V., Tomar, R. S., Patel, S., & Golakiya, B. A. (2010). *Molecular biology and biotechnology: Microbial methods*. NIPA, New Delhi, India. 6. Reeve, R. N. (2002). *Introduction to environmental analysis* (1st ed.). John Wiley & Sons Ltd., Chichester, West Sussex, England. 7. Skoog, D. A., West, D. M., & Holler, F. J. (2001). *Fundamentals of analytical chemistry* (7th ed.). Harcourt Asia PTE Ltd., Singapore. 8. Willard, H., Merritt, L., Dean, D. A., & Settle, F. A. (1998). *Instrumentation methods of analysis* (7th ed.). Wordsworth, Belmont, California. 9. Wilson, K., & Walker, J. (2013). *Principles and techniques of biochemistry and molecular biology*. Cambridge University Press, Cambridge, United Kingdom.

Title of the Course	Analytical Techniques Practical
Course Code	ENV-5009
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic knowledge of chemistry and biology.			
Course Objectives:	• This course develops the skills for techniques and instrumentation. • To understand the principles and working of various instruments used in environmental analysis.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Understand the use of various analytical methods in environmental analysis.		PSO 1, PSO 2	
	CO 2. Apply knowledge of environmental analysis of samples using the principles of chromatography, centrifugation.		PSO 1, PSO 2	
	CO 3. Explain the use of spectroscopic assays in environmental analysis.		PSO 1, PSO 2	
	CO 4. Interpret the results of environmental sample analysis.		PSO 1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	1. Demonstration of cell structure and components by SEM.	**30**	CO1	K2
	2. Demonstration of GC/ FTIR/ NMR/ MALDI-TOF.		CO2, CO3	K2, K3
	3. Demonstration of LC-MS.		CO3	K2
	4. Demonstration of TOC analyser.		CO1	K2
	5. Elucidation of the structure of cellular metabolites using IR, NMR and Mass profiles.		CO3, CO4	K2, K3
Pedagogy:	Practicals/ Tutorials/ Research papers/ assignments/ presentations/ self-study/ Videos			
References/ Readings:	1. Cooper, T. G. (2011). *The tools of biochemistry* (1st ed.). Wiley India Pvt. Ltd. New Delhi, India 2. Goswami, C., Paintal, A., & Narain, R. (2011). *Handbook of bioinstrumentation*. Wisdom Press, New Delhi, India. 3. Jayaraman, J. (2011). *Laboratory manual in biochemistry*. New Age International Publishers, New Delhi, India 4. Parakhia, M. V., Tomar, R. S., Patel, S., & Golakiya, B. A. (2010). *Molecular biology and biotechnology: Microbial methods*. NIPA. New Delhi, India. 5. Wilson, K., & Walker, J. (2013). *Principles and techniques of biochemistry and molecular biology*. Cambridge University Press, Cambridge, United Kingdom.			

Title of the Course	Environmental Microbiology
Course Code	ENV-5010
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip students with a thorough understanding of the microbial world, focusing on the diversity, ecology, and physiological roles of microorganisms in various environments, and explore their impacts on ecosystem functioning, human health, and sustainable development.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand classification systems and microbial diversity from diverse environments.	PSO 1, PSO 4
	CO 2. Review techniques to study microbial communities and interpret their ecological interactions.	PSO 1, PSO 4
	CO 3. Assess the roles of microorganisms in ecological processes and their impact on biodiversity, environmental stability, and public health.	PSO 1, PSO 4, PSO 6
	CO 4. Evaluate microbial solutions for sustainability in agriculture, energy, environment, and industry.	PSO 1, PSO 4, PSO 6

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to the microbial world and a brief history of microbiology; microbial groups (Archaea, bacteria, protists, fungi, viruses) from diverse terrestrial and aquatic environments; Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; concepts of extremophilic microorganism (Thermophiles, halophiles, acidophiles, alkaliphiles, piezophiles, and psychrophiles). Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment; microbial associations (plant-microbe, animal-microbe): mutualism, protocooperation, commensalism, syntrophism, predation, competition, amensalism and parasitism.	**15**	CO1, CO2	K2, K5
Module 2:	Impacts of microorganisms on the environment and humans: role of microorganisms in food web, biogeochemical cycling of carbon, nitrogen and phosphorus. microorganisms and climate change, range extension of species; disease outbreaks and epizootics; Microorganisms in Global Biodiversity and Conservation: Keystone Microbial Species, Microbiomes in Conservation, Extinction Risks Due to Pathogens; antibiotic-resistant bacteria and their implications; Microbial Threats and Bioterrorism; ballast water and bio-invasion: concept, implications and preventive measures, ballast water management convention, biofilms, bio-fouling and corrosion associated with shipping industry- progression, impacts and preventive measures.	**15**	CO3	K5
Module 3:	Environmental microbiology in sustainable development, microorganisms in agriculture: nitrogen-fixing bacteria, Mycorrhizae, phosphate-solubilizing bacteria, plant growth-promoting Rhizobia, biocontrol agents, Genetically Modified Organisms. Microorganisms for food security, clean energy, water quality, bioactive compounds for therapeutics, bioenzymes (Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) animal feed production); mineral recovery (Bioleaching of copper, gold and uranium) bioremediation of environmental pollutants (Petroleum hydrocarbons and pesticides heavy metal and xenobiotics)**.**	**15**	CO4	K6

Pedagogy:	Lectures/ tutorials/ assignments/ case study/ self-study.
References/ Readings:	1. Bertrand, J. C., & Coumette, P. (2015). *Environmental microbiology: Fundamentals and applications*. Springer. Dordrecht, Netherlands. 2. Medigan, M. T., Bender, K. S., Bukley, D. H., Sattley, W. M., & Stahl, D. A. (2019). *Brock biology of microorganisms* (15th ed.). Pearson. Boston, MA, USA. 3. Munn, C. (2020). *Marine microbiology: Ecology and applications* (3rd ed.). Garland Science. Boca Raton, FL, USA. 4. Naik, M. M., & Dubey, S. K. (2017). *Marine pollution and microbial remediation*. Springer. Singapore. 5. Satyanarayana, T., Johri, B., & Anil, T. (2012). *Microorganisms in environmental management*. Springer. Dordrecht, Netherlands. 6. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2017). *Prescott's microbiology* (10th ed.). McGraw-Hill Education. New York, USA.

Title of the Course	Environmental Microbiology Practical
Course Code	ENV-5011
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip students with hands-on skills and a comprehensive understanding of microbiological techniques applied in environmental monitoring, microbial isolation, and the assessment of microbial interactions in various ecosystems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate the ability to assess and evaluate the microbiological quality of air and water.	PSO 1, PSO 2, PSO 4
	CO 2. Gain proficiency in isolating symbiotic and environmentally significant microorganisms.	PSO 1, PSO 4
	CO 3. Perform culture-independent analysis of microbial communities by extracting genomic DNA from environmental samples and identifying microorganisms using sequence data.	PSO 1, PSO 4
	CO 4. Develop the ability to isolate and screen bacteria capable of metal and hydrocarbon transformations to be used for bioremediation.	PSO 1, PSO 4, PSO 6

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Assessment of microbiological quality of air.	30	CO1	K3, K4, K5, K6
	2. Isolation of symbiotic nitrogen-fixing rhizobacteria from the root nodules.		CO2	K3, K4, K5
	3. Isolation of bioluminescent bacteria from marine organisms.		CO2	K3, K4, K5
	4. Detection and enumeration of coliforms in water samples using the Most Probable Number (MPN) method.		CO1	K3, K4, K5
	5. Isolation of microbial genomic DNA from environmental sample (Sediment/Water) and identification of select microorganisms using provided sequence data.		CO3	K3, K4, K5
	6. Isolation and screening of bacteria capable of metal and hydrocarbon transformation.		CO4	K3, K4, K5
Pedagogy:	Laboratory experiments/ field trips.			
References/ Readings:	1. Amaresan, N., Patel, P., & Amin, D. (Eds.). (2022). *Practical handbook on agricultural microbiology*. Springer, New York, USA. 2. Davis, L. G., Dibner, M. D., & Battey, J. F. (1986). *Basic methods in molecular biology*. Elsevier, New York, USA. 3. Kamlage, B. (1996). *Methods for general and molecular bacteriology*. In P. Gerhardt, R. G. E. Murray, W. A. Wood, & N. R. Krieg (Eds.), American Society for Microbiology, Washington, D.C., USA. 4. Naik, M. M., & Dubey, S. K. (2017). *Marine pollution and microbial remediation*. Singapore 5. Pepper, I. L., Gerba, C. P., & Brendecke, J. W. (1995). *Environmental microbiology: A laboratory manual*. Academic Press, San Diego, CA, USA. 6. Parmar, P., Shukla, A., Saraf, M., & Patel, B. (2020). Isolation of bioluminescent bacteria from marine organisms. Indian Journal of Geo Marine Sciences 49(03), 471-476.			

Title of the Course	Environmental Toxicology and Risk Assessment
Course Code	ENV-5012
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip students with foundational knowledge in environmental toxicology and risk assessment for evaluating the impact of pollutants on human and ecological health.	
Course Outcomes:		Mapped to PSO
	CO 1. Define key concepts in toxicology, including dose-response relationships, exposure pathways, and toxicity mechanisms.	PSO 1, PSO 4
	CO 2. Distinguish between different types of toxic effects and analyse their implications for human and ecological health.	PSO 1, PSO 4
	CO 3. Explain the mechanism of environmental contaminants.	PSO 1, PSO 4
	CO 4. Use basic toxicological data to perform exposure assessments and calculate risk estimates.	PSO 1, PSO 4

	CO 5. Critically assess risk assessment methodologies and regulatory guidelines used in environmental health decision-making.		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Definition and importance; historical incidents of environmental toxicology; types/classification of toxicants: natural and anthropogenic; pathways of toxicant: air, water, soil, and food; dose and response relationship; toxicity; toxicokinetic and toxicodynamic; antimicrobial resistance; toxicant uptake	**15**	CO 1	K1
Module 2:	Mechanisms of toxic action: oxidative stress, neurotoxicity, immunotoxicity, and endocrine disruption; Biomarkers of exposure, effect, and susceptibility; biomarkers of exposure, effect, and susceptibility; bioaccumulation, bioconcentration, and biomagnification; effects of pollutants on aquatic and terrestrial ecosystems; methods in ecotoxicology: acute and chronic toxicity tests; biotransformation and elimination; environmental forensics; teratogenesis, carcinogenesis, mutagenesis	**15**	CO 2, CO 3	K2, K4
Module 3:	Risk assessment: Definition, scope, and importance; steps in risk assessment; risk characterization; risk management and communication; case studies; tools and techniques in risk assessment; regulatory frameworks; application of risk assessment in industrial and environmental contexts	**15**	CO 4, CO 5	K3, K5
Pedagogy:	Lectures/assignments/self-study/field trip			
References/ Readings:	1. Cockerham, L. G., & Shane, B. S. (2019). *Basic environmental toxicology*. CRC Press. Boca Raton, FL, USA. 2. Hughes, W. (1996). *Essentials of environmental toxicology*. CRC Press, London, United Kingdom. 3. Newman, M. C. (2019). *Fundamentals of ecotoxicology: The science of pollution* (5th ed.). CRC Press. Boca Raton, FL, USA. 4. Rand, G. M. (2020). *Fundamentals of aquatic toxicology: Effects, environmental fate, and risk assessment*. CRC Press, Boca Raton, FL, USA. 5. Torres, J. A., & Bobst, S. (2015). *Toxicological risk assessment for beginners*. Springer, Cham, Switzerland. 6. Wright, D. A., & Welbourne, P. (2002). *Environmental toxicology*. Cambridge University Press, Cambridge, United Kingdom.			

Title of the Course	Environmental Toxicology and Risk Assessment Practical
Course Code	ENV-5013
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide hands-on experience in toxicity testing, pollutant impact assessment, and risk analysis using biological and environmental indicators for evaluating ecological and human health risks.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the experimental procedures used in environmental toxicity testing.	PSO 1, PSO 4
	CO 2. Describe the principles behind LC_{50} determination, dose-response relationships, and pollutant impact assessment.	PSO 1, PSO 4
	CO 3. Devise laboratory experiments to evaluate toxicity and the effects of pollutants on biological systems.	PSO 1, PSO 4
	CO 4. Prepare dose-response curves and formulate basic environmental risk assessments based on experimental outcomes.	PSO 1, PSO 4

	CO 5. Classify marine debris/plastics by size and analyze patterns to assess potential environmental impacts.		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Determine impact of heavy metals of the growth of test organism/plankton.	**30**	CO1, CO3	K2, K5
	2. Determination of LC_{50} using a test organism/plankton.		CO2	K1
	3. Determine the effect of pesticide/heavy metal on seed germination.		CO3	K5
	4. Preparation of dose-response curves, risk assessment and data interpretation.		CO4	K2
	5. Size classification of marine debris/plastic.		CO 5	K3, K5
Pedagogy:	Laboratory experiments/field trips			
References/ Readings:	1. Goh, B.P.L., Tong, J.J.L., Tan, L.T., Lim, K. & Tun, K.P.P. (2020). Marine Ecotoxicology Biomonitoring Made Easy – Six Biomarker Assays for the Citizen Scientist. National Institute of Education, Nanyang Technological University, National Parks Board, Singapore. 2. Goh, B.P.L., Lai, C.H., Tan, L.T., Yap, N.W.L. & Dissanayake, A. (2014). Handbook of Marine Ecotoxicology Techniques. National Institute of Education, Nanyang Technological University. National Parks Board, Singapore. 3. Kroon, F. J., Motti, C. E., Jensen, L. H., & Berry, K. L. (2018). Classification of marine microdebris: A review and case study on fish from the Great Barrier Reef, Australia. Science Reports, 8(1), 1-15. London, United Kingdom.			

Title of the Course	Waste Management
Course Code	ENV-5014
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To understand the concept of waste, its types, classification, and characterization, recognize the importance of waste management and its environmental and public health implications, learn strategies and methods for waste disposal and treatment, and be aware of the role of individual and central laws in managing waste.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify and classify different types of wastes and analyze their environmental, social, and economic impacts.	PSO 1, PSO 4
	CO 2. Evaluate various waste treatment methods in terms of efficiency, cost, and environmental sustainability.	PSO 1, PSO 4
	CO 3. Differentiate types and management of hazardous wastes.	PSO 1, PSO 4
	CO 4. Analyze various policies, regulations, and guidelines for effective waste management and generate awareness among the general public.	PSO 1, PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Types of wastes, Classification of waste based on physical properties: Solid, liquid, gaseous, and semi-solid waste; Sources and categories of waste generation. Waste Generation and Its Environmental Impact, Principles of Waste Management- Waste Hierarchy, Sustainable Waste Management Principles, Integrated Waste Management Systems. Characteristics of municipal solid waste (physical, chemical and biological). waste prevention and waste reduction techniques; Factors affecting the solid waste generation; Storage, collection and transportation of municipal solid waste; Disposal of Municipal solid waste- Landfilling, Planning and design, construction and operational practices; quality check and control measures; Composting; biogas production from municipal solid waste; and Incineration of waste, Residues and its utilisation; co-combustion; Pyrolysis; Gasification; Refuse Derived Fuel; solid recovered fuel.	**15**	CO 1, CO 2	K1, K2, K3, K4, K5
Module 2:	Definition and types of liquid waste: Domestic sewage, industrial wastewater, agricultural runoff, leachate, and stormwater. Characteristics of liquid waste: Physical, chemical, and biological properties. Environmental impacts of untreated liquid waste. Sewage treatment processes: Single dwelling, Municipal waste treatment plants- Primary Treatment Techniques (Screening and grit chambers, Sedimentation tanks for settling suspended solids). Secondary Treatment Techniques: Biological treatment methods (Aerobic processes- Activated sludge process, trickling filters, oxidation ponds; Anaerobic processes- Upflow Anaerobic Sludge Blanket reactors, anaerobic lagoons). Tertiary and advanced Treatment techniques: (Chemical processes: Coagulation, flocculation, chlorination, and ozonation). Physical processes: Membrane filtration (microfiltration, ultrafiltration, reverse osmosis), constructed wetlands and bioreactors.	**15**	CO 1, CO 2	K1, K2, K3, K4 K5
Module 3:	Hazardous waste: Definition, sources, types (biomedical, nuclear and e-waste), effects and management. Principles of Industrial waste treatment: sources of pollution, physical-chemical and biological properties; characteristics and composition of wastes, including waste reduction, treatment of Dairy, Distillery, Sugar, and Antibiotic Industries; Use of SCADA systems for waste management;	**15**	CO 1, CO 2, CO 4	K1, K2, K3, K4, K5

	Biotechnological and Nanotechnological Advances in Waste Management. Environmental Regulation for Waste Management- Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, E-Waste (Management) Rules, 2016 and 2022 Amendments, Plastic Waste Management Rules, 2016 and 2021 Amendments. Involvement of the public in waste management. Entrepreneurship in Waste Management.			
Pedagogy:	Lectures/tutorials/assignments/case study/self-study.			
References/ Readings:	1. World Health Organization. (2024). Chapter 4: Solid waste. In *Compendium of WHO and other UN guidance in health and environment, 2024 update*. World Health Organization, Geneva. 2. Englande, A. J., & Jin, G. (2006). Application of biotechnology in waste management for sustainable development: An overview. *Management of Environmental Quality: An International Journal, 17*(4), 467–477. 3. Hammer, M. J. (1986). *Water and wastewater technology*. Englewood Cliffs, NJ, USA. 4. Lie, D. H., & Liptak, B. G. (2000). *Hazardous wastes and solid wastes*. Lewis Publishers, Boca Raton, FL, USA. 5. Pichtel, J. (2005). *Waste management practices: Municipal, hazardous, and industrial*. CRC Press, Boca Raton, FL, USA. 6. Vallero, D. A. (2022). *Hazardous waste management* (3rd ed.). Academic Press, Cambridge, MA, USA.			
Web Resources:	http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php			

Title of the Course	Waste Management Practical
Course Code	ENV-5015
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To analyze waste generation patterns and management challenges in local communities, understand operational processes in wastewater and solid waste treatment facilities, and evaluate innovative treatment technologies while assessing wastewater quality through lab analysis.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Conduct laboratory analyses of wastewater sample, measuring key chemical and biological parameters to evaluate water quality and treatment efficiency.	PSO 1, PSO 2, PSO 4, PO6
	CO 2. Prepare and analyze the bio-compost.	PSO 1, PSO 4, PO6
	CO 3. Perform the clarification of the dye-contaminated wastewater using nanoparticles.	PSO 1, PSO 4, PSO 6
	CO 4. Gain insights into the operational mechanisms and management strategies employed in wastewater, solid waste treatment and biomedical waste facilities	PSO 1, PSO 4

	through field observations.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. To analyze key physicochemical and biological parameters specific to the wastewater sample.	30	CO1	K3, K4, K5, K6
	2. Perform bio-composting.		CO2	K3, K4, K5, K6
	3. Perform compost analysis- pH, Electrical Conductivity, determination of nitrate, phosphate, potassium etc.		CO2	K3, K4, K5, K6
	4. Use of nanoparticles (TiO_2/ ZnO/ Ag) for the clarification of dye-contaminated wastewater.		CO3	K3, K4, K5, K6
	5. Field visit to waste treatment facility to observe and understand the working processes and management mechanisms, and prepare a detailed report on the findings.		CO4	K3, K4, K5
Pedagogy:	Laboratory experiments / field trips/ field reports and presentations.			
References/ Readings:	1. Authority, E. P., & Victoria, A. (2000). *A guide to the sampling and analysis of waters, wastewaters, soils and wastes*. Environmental Protection Authority, Victoria, Australia. 2. Elbadawy, H. A., Elhusseiny, A. F., Hussein, S. M., & Sadik, W. A. (2023). Sustainable and energy-efficient photocatalytic degradation of textile dye assisted by ecofriendly synthesized silver nanoparticles. *Scientific Reports, 13*(1), 2302. 3. Iram, S., Kanwal, S., Ahmad, I., Tabassam, T., Suthar, V., & Mahmood-ul-Hassan, M. (2013). Assessment of physicochemical parameters of wastewater samples. *Environmental Monitoring and Assessment, 185*, 2503–2515. 4. Head, K. H., & Epps, R. (2014). *Manual of soil laboratory testing*. Whittles Publishing, Caithness, Scotland. 5. Hung, Y. T. (2014). *Handbook of environment & waste management* (Vol. 2). World Scientific, Singapore 6. Okafor, N. (2011). *Environmental microbiology of aquatic and waste systems*. Springer Science & Business Media. Dordrecht, Netherlands.			
Web Resources:	https://www.vlab.co.in/			

Discipline Specific Elective Courses

Title of the Course	Environmental Ethics
Course Code	ENV-5207
Number of Credits	04
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce students to the fundamental concepts, terminology, and historical developments in environmental ethics. • Analyze different value systems and moral theories pertaining to environmental decision-making. • Propose innovative, ethically sound solutions to environmental problems that integrate moral reasoning and sustainable technology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Analyze different theories of environmental ethics.	PSO 4, PSO 6
	CO 2. Develop and apply the essential forms of argumentation that can be offered for preserving natural entities and ensure the sustainable use of natural resources.	PSO 4, PSO 6

	CO 3. Define and understand the key concepts, terminology, historical developments and ethical perspectives.		PSO 1, PSO 6	
	CO 4. Enhance the knowledge and abilities required to address complex environmental challenges by guiding students to critically examine how their choices and actions impact the environment.		PSO 1, PSO 6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to environmental ethics; Definition and Scope; Historical context; Philosophical challenges; Ethical framework and perspectives	**15**	CO3, CO4	K2, K 5
Module 2:	Value and Nature; Moral theories (Consequentialism, Virtue Ethics and Kantianism); Intrinsic value and Instrumental values; Anthropocentrism; Challenges to Anthropocentrism.	**15**	CO1, CO2	K3, K4, K6,
Module 3:	Ecology; Land ethics; Deep ecology & Shallow ecology; Bio centrism & Eco-centrism; Speciesism.	**15**	CO3	K1, K2
Module 4:	Technology and Environmental Impact; Ethics related to sustainable technology; Ethical issues in technological development; Environmental justice and technology; Contemporary issues (over-exploitation of natural resources, pollution, climate change), Technology and Environmental Ethics.	**15**	CO2, CO4	K3, K5, K6
Pedagogy:	Lectures/ assignments/ workshops/ campus walks/ documentaries/ discussions/ presentations			
References/ Readings:	1. Attfield, R. (2014). *Environmental philosophy*. Polity Press, Cambridge, United Kingdom 2. Bassey, S. (2020). Technology, environmental sustainability, and the ethics of anthropoholism. *Przestrzeń Społeczna*, 16(1), 45–58. 3. Epting, S. (2010). Questioning technology's role in environmental ethics: Weak anthropocentrism revisited. *Interdisciplinary Environmental Review*, *11*(1). Geneva, Switzerland. 4. Gardiner, S. M., & Thompson, A. (2017). *The Oxford handbook of environmental ethics*. Oxford University Press, Oxford, United Kingdom.			

	5. Grim, J. A. (Ed.). (2001). *Indigenous traditions and ecology: The inter-being of cosmology and community*. Harvard University Press, MA, USA. 6. Jamieson, D. (2008). *Ethics and environment: An introduction*. Cambridge University Press, Cambridge, United Kingdom. 7. Jaquet, F. (2019). Is speciesism wrong by definition? *Journal of Agricultural and Environmental Ethics, 32*(3). Dordrecht, Netherlands. 8. Kaplan, D. M. (2017). *Philosophy, technology, and the environment*. MIT Press. Cambridge, MA, USA 9. Kopnina, H., Washington, H., Taylor, B., & Piccolo, J. J. (2018). Anthropocentrism: More than just a misunderstood problem. *Journal of Agricultural and Environmental Ethics*, *31*(1), 109–127. 10. Passmore, J. (1974). *Man's responsibility for nature*. Charles Scribner's Sons, New York, USA. 11. Sandler, R. (2017). *Environmental ethics: Theory in practice*. Oxford University Press, Oxford, United Kingdom 12. Taylor, P. W. (1986). *Respect for nature: A theory of environmental ethics*. Princeton University Press, Princeton, NJ, USA. 13. Weaver, P., Jansen, L., Grootveld, G., Spiegel, E., & Vergragt, P. (2000). *Sustainable technology development*. Routledge, London, United Kingdom.

Title of the Course	Environmental Issues and Perspectives
Course Code	ENV-5208
Number of Credits	04
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide a conceptual foundation for understanding contemporary environmental concerns • To foster the ability to apply theoretical knowledge to practical environmental problems • To develop critical thinking on sustainability and environmental futures	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand ecological concepts and interdisciplinary approaches to environmental studies to critically examine human-nature relationships.	PSO 1
	CO 2. Analyse the impacts of human population dynamics, urbanisation, and development on natural resources	PSO 1, PSO 4
	CO 3. Identify and evaluate contemporary environmental issues such as pollution, food security, and global warming through scientific and social perspectives.	PSO 1, PSO 3, PSO 6

	CO 4. Examine the social dimensions of environmental issues		PSO1, PSO 4, PSO 6	
	CO 5. Apply principles of sustainability, environmental ethics, and ecological citizenship to propose community-based strategies for environmental conservation and livelihood security.		PSO 1, PSO 3, PSO 4, PSO 6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Understanding Environmental Thought: Environmental heritage and the human dimension of environmental science; Sociological perspectives on environment; Interdisciplinary and multidisciplinary approaches to environment studies; Biological, ecological, and social ecological orientations.	**15**	CO1	K1, K2
Module 2:	Environmental Issues and Concerns: Urbanisation and environmental stress; food systems, agriculture, and environment; Climate change and global warming; Consumerism, and ecological footprints	**15**	CO1, CO3, CO4,	K2, K4, K5
Module 3:	Social Issues and Environment**:** Development, displacement, and rehabilitation; Gender and the Environment**;** Environmental Movements; Social-Ecological Issues in Goa.	**15**	CO2, CO4	K2, K4, K5
Module 4:	Towards a Sustainable Environmental Future**:** Sustainable Development in the Indian Context; Indigenous Knowledge and Environmental Management; Environmental Technologies for a Sustainable Future**;** Role of education, community participation, and ecological citizenship.	**15**	CO4, CO5	K2, K3, K6
Pedagogy:	Lectures, assignments, interactive sessions, campus walks, Field Visits, documentaries, presentations, role plays.			
Texts:	1. Alvares, C. (2002). *Fish Curry and Rice: A Source Book on Goa, Its Ecology, and Lifestyle.* Goa Foundation, Panaji, Goa. 2. Basu, M., & Xavier, S. (2016). *Fundamentals of environmental studies*. Cambridge University Press, Cambridge, United Kingdom. 3. Gadgil, M., & Guha, R. (2000). *Ecology and equity*. Oxford University Press, New Delhi, India. 4. Guha, R. (2000). *Environmentalism: A global history*. Oxford University Press, New York, USA.			

	5. Joseph, B. (2009). *Environmental studies* (2nd ed.). Tata McGraw-Hill, New York, USA. 6. Krishna, S. (1996*). Environmental politics*. Sage Publications, New Delhi, India. 7. Rangarajan, M. (Ed.). (2007). *Environmental issues in India: A reader*. Dorling Kindersley, New Delhi, India.
References/ Readings:	1. Carolyn, M. (Ed.). (1996). *Ecology*. Rawat Publications, Rajasthan, India. 2. Gadgil, M., & Guha, R. (2000). *Use and abuse of nature*. Oxford University Press, New Delhi, India. 3. Goudie, A. S. (2019). *Human impact on the natural environment: Past, present and future* (8th ed.). Wiley-Blackwell, Oxford, United Kingdom. 4. Rai, S. C., & Mishra, P. K. (Eds.). (2023). *Traditional ecological knowledge of resource management in Asia*. Springer, Cham, Switzerland. 5. Shiva, V. (1991). *Ecology and the politics of survival: Conflicts over natural resources in India*. Sage Publications, New Delhi, India. 6. Sonak, S. (2014). *Khazan ecosystems of Goa: Building on indigenous solutions to cope with global environmental change*. Springer Nature, Dordrecht, Netherlands. 7. Weeks, J. R. (2012). *Population: An introduction to concepts and issues* (10th ed.). Cengage Learning, Boston, MA, USA.
Web Resources:	1. Agarwal, B. (1992). The gender and environment debate: Lessons from India. *Feminist Studies*, *18*(1), 119–158. https://doi.org/10.2307/3178217 2. Basu, S. (2016). Consumerism of e-products and its global effect on climate change. In *Climate change: Issues and challenges to society, environment and development* (pp. 91–97). ISBN: 978-81-929776-1-4 3. Berkes, F. (2007). Community-based conservation in a globalized world. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(39), 15188–15193. https://doi.org/10.1073/pnas.0702098104 4. Borthakur, A., Singh, P. (2022). Understanding consumers' perspectives of electronic waste in an emerging economy: a case study of New Delhi, India. *Energ. Ecol. Environ.* **7**, 199–212 https://doi.org/10.1007/s40974-022-00242-9 5. Guerra, J.B.S.O.A., Hoffmann, M., Bianchet, R.T. *et al.* (2022). Sustainable development goals and ethics: building "the future we want". *Environ Dev Sustain* 24, 9407–9428 https://doi.org/10.1007/s10668-021-01831-0 6. Ganguly, V. (2005). Displacement, Rehabilitation and Resettlement: The Case of Maldhari Families of Gir Forest. Sociological Bulletin, 54(1), 3-17. https://doi.org/10.1177/0038022920050101 7. Guha, D. (n.d). Consumerism's Heavy Burden: Impact of Bulky Waste Generation on Society and Environment.

https://saahas.org/wp-content/uploads/2024/05/Blog-on-Consumerism.pdf

8. Patel, S.K., Sharma, A. & Singh, G.S. (2020). Traditional agricultural practices in India: an approach for environmental sustainability and food security. *Energ. Ecol. Environ.* 5, 253–271 https://doi.org/10.1007/s40974-020-00158-2
9. Shukla, S.R., Sinclair, A.J. (2010). Strategies for Self-organization: Learning from a Village-level Community-based Conservation Initiative in India. *Hum Ecol* 38, 205–215 https://doi.org/10.1007/s10745-010-9301-y

Title of the Course	Sustainable Development and Resource Management
Course Code	ENV-5209
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Introduce the ideas of Sustainable Development and resource management for a developing world. • Explain the goals and targets of UN's Sustainable Development Goals • Teach how to measure the achievements of SDGs. • Explain the trade-offs involved in operationalizing sustainability planning. • Familiarise with the plural perspectives on the environment. • Examine the role of markets and policies in resource management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain and critically analyze the SDGs.	PSO 1
	CO 2. Measure the achievements in the SDGs, especially in the Indian context.	PSO 1

	CO 3. Critically evaluate the role of markets and policies in resource management.		PSO 1, PSO 6	
	CO 4. Apply the economic tools for the preliminary application of policies for sustainable resource use.		PSO 1, PSO 6	
	CO 5. Analyze the trade-offs in sustainability planning.		PSO 1	
	CO 6. Explain the plural perspectives on the environment.		PSO 1, PSO4, PSO 6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Sustainable Development: Definition and concept of sustainable development, measures of sustainable development – the UN Sustainable Development Goals (SDGs); objectives of Sustainable development, Policy options for Sustainable growth. Role of Industry, Agriculture and Services in sustainability. Link between Sustainable Development and Climate Change, Implementation of Sustainable Development and Climate Change Policies.	**15**	CO1, CO2	K2, K5
Module 2:	Sustainable development in India: India's efforts at achieving SDGs; technology transformation, industrial development and environmental pollution, Sustainable management of land, water and air. Equity and resource management. Role of communities in environmental management. Environmental movements and community restoration.	**15**	CO2, CO3	K5
Module 3:	Resource Management: Management of environmental resources. Understanding the role of markets, government and communities. Meaning of externalities, environmental policy in the presence of externalities. Missing Markets. Public Goods, Common Property Resources, Coase Theorem and Issues in Property Rights; Pigouvian Taxes, Subsidies, Tradable Permits, Price v/s Quantity tools	**15**	CO3, CO4, CO5, CO6	K2, K3, K4, K5
Pedagogy:	Lectures/ assignments/ workshops/ campus walks/ documentaries/ discussion/ presentations			
References/	1. Conrad, J. M., & Rondeau, D. (2020). *Natural resource economics: Analysis, theory, and applications*. Cambridge			

Readings:	University Press, Cambridge, United Kingdom. 2. Gadgil, M., & Guha, R. (2000). *Use and abuse of nature*. Oxford University Press, New Delhi, India. 3. Gadgil, M., & Guha, R. (1995). *Ecology and equity*. Oxford University Press, New Delhi, India. 4. Haque, A. K. E., Mukhopadhyay, P., Nepal, M., & Shammin, M. R. (Eds.). (2021). *Climate change and community resilience: Insights from South Asia*. Springer, Cham, Switzerland. 5. Hardin, G. (1968). The tragedy of the commons. *Science, 162*(3859), 1243–1248. 6. Harris, J. M., & Roach, B. (2022). *Environmental and natural resource economics: A contemporary approach*. Routledge, New York, USA. 7. Leopold, A. (1972). *A Sand County almanac and sketches here and there*. Oxford University Press, New York, USA. 8. Prasad, R., Jhariya, M. K., & Banerjee, A. (Eds.). (2022). *Advances in sustainable development and management of environmental and natural resources: Economic outlook and opinions* (1st ed.). Apple Academic Press, Oakville, Canada. 9. Carson, R. (2012). *Silent spring* (50th anniversary ed.). Penguin Classics. London, United Kingdom 10. Rangarajan, M. (Ed.). (2007). *Environmental issues in India: A reader*. Dorling Kindersley. Noida, India.

Title of the Course	Sustainable Development and Resource Management Practical
Course Code	ENV-5210
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Introduce simple computational models of resource management. • To understand resource allocation problems using numerical models. • To explore optimal depletion and optimal harvest of renewable and non-renewable resources.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Create simple models of resource management.	PSO 1
	CO 2. Apply economic principles to forest management, including growth evaluation, optimal rotation analysis, and old-growth forest valuation.	PSO 1
	CO 3. Identify the role of different institutional rules in fostering sustainable development.	PSO 1, PSO 4, PSO 6
	CO 4. Evaluate the transition paths for renewable and non-renewable resources.	PSO 1

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Optimal Depletion Problem and Optimal Harvest Problem.	**30**	CO1	K6
	2. Economics of Fisheries, Fishery Production Functions, The Yield–Effort Function, Static and Dynamic Model of Open Access, Present Value Maximization.		CO1	K3, K6
	3. The Economics of Forestry, The Volume Function and Mean Annual Increment, The Optimal Single Rotation, The Faustmann Rotation, the Optimal Stock of Old-Growth Forest.		CO2	K3
	4. The Economics of non-renewable Resources, Solving a Simple Model, Hotelling's Rule, Estimating the Inverse Demand Curve, Extraction and Price Paths in the Competitive Industry, Extraction and Price Paths under Monopoly, Reserve-Dependent Costs, Exploration, The Economic Measure of Scarcity.		CO1, CO3, CO4	K2, K5
Pedagogy:	Lectures/ assignments/ workshops/ discussion/ presentations			
References/ Readings:	1. Conrad, J. M. (2006). *Resource economics* (Reprint ed.). Cambridge University Press, MA, USA. 2. Conrad, J. M., & Rondeau, D. (2020). *Natural resource economics: Analysis, theory, and applications* (1st ed.). Cambridge University Press, Cambridge, UK. 3. Dayal, V. (2014). *The environment in economics and development: Pluralist extensions of core economic models*. Springer, New Delhi, India.			