Std. Com. X AC- 3
13.08.2021

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

M I N U T E S

of the 3rd Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

13th August, 2021

Time

10.30 a.m.

Venue
Council Hall
Goa University

Prof. H.B Menon, Dean, School of Earth, Ocean & Atmospheric Sciences, Prof. Nina Caldeira, Dean, Faculty of Languages & Literature, Prof. Aparajita Gangopadhyay, Dean, School of International & Area Studies and Prof. Anna Neena George, Dean, Faculty of Education were invited to attend the meeting.

Prof. M. S. Dayanand, Dean, Goa Business School, Goa University sought leave of absence.

The Chairperson (Vice-Chancellor) welcomed the members and thanked them for attending the Third meeting of the Standing Committee of the X Academic Council. He also welcomed Prof. Janet Fernandes e De Souza who was nominated as member in place of Dr. Naguesh Colvalcar who had superannuated. The Chairperson thanked Dr. Colvalcar for his services to the Standing Committee.

The Chairperson (Vice-Chancellor) further informed that since the Registrar, Prof. Radhika S. Nayak could not be present for the meeting, she had requested Shri Donald A.E. Rodrigues, Joint Registrar Academic to function as the Member Secretary.

Thereafter, the agenda was taken up for discussion.

D	**DISCCUSSION**
D 3	**BOARD OF STUDIES**
D 3.1	**Minutes of the Board of Studies in Environmental Studies held on 10th August 2021.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Environmental Studies held on 10th August 2021 with the following observations: 1. Chairperson, Board of Studies was requested to standardize the references. 2. The sub-title to Course ESO 355 Environmental Security to be deleted. 3. The Pre-requisite to Course ESO 356 to read as: "No pre-requisite other than interest in the subject of History and willingness to put in sincere efforts to acquire knowledge in this area." It was suggested to change the name of Board of Studies to BoS in Environmental Science. **(Action: Assistant Registrar Academic-PG)**
D 3.2	**Minutes of the Board of Studies in International Hospitality Management held on 08th July 2021.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in International Hospitality Management held on 08th July 2021. **(Action: Assistant Registrar Academic-PG)**
D 3.3	**Minutes of the Meeting of Board of Studies in International Studies held on 20th July 2021.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in International Studies held on 20th July 2021. The Chairperson was requested to add the Book "The Future History of the Arctic"

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A G E N D A

For the 3rd Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

13th August, 2021

Time

10.30 a.m.

Venue
Council Hall,
Goa University

Std. Com.X AC- 3
13-08-2021

Second Meeting of the Standing Committee of the X Academic Council

Date: 13-08-2021

Time: 10.30 a.m.

Venue: Council Hall, Office of the Vice-Chancellor, Goa University.

D	**DISCUSSIONS**
D 3	**BOARDS OF STUDIES**
D 3.1	**Minutes of the Board of Studies in Environmental Studies held on 10th August 2021.** **Part A**. i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NIL ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **The Board of studies recommended twenty nine optional courses for second and third Semesters of M.Sc./M.A in Environmental Science Annexurel (Refer Page no 1)** **Part B** i. Scheme of Examinations at undergraduate level: NIL ii. Panel of examiners for different examinations at the undergraduate level: NIL iii. Scheme of Examinations at postgraduate level: NIL iv. Panel of examiners for different examinations at post-graduate level: NIL **Part C.** 1. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection: NIL **Part D** i. Recommendations regarding general academic requirements in the Departments of University or affiliated colleges: NIL ii. Recommendations of the Academic Audit Committee and status thereof: NIL **Part E.** i. Recommendations of the text books for the course of study at undergraduate level: NIL ii. Recommendations of the text books for the course of study at post graduate

level:

NIL

Part F.

Important points for consideration/approval of Academic Council

i. The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below

a) The Board of Studies in Environmental Science has recommended all optional courses, twenty nine in number, to be offered in the third and fourth semesters of M.Sc./M.A in Environmental Science

ii. The declaration by the Chairperson that the minutes were readout by the Chairperson at the meeting itself.

Date: 10/08/2021
Place: Goa University, Taleigao Plateau

Sd/-
Signature of the Chairperson

Part G. The Remarks of the Dean of the Faculty

i. The minutes are in order
ii. The minutes may be placed before the Academic Council with remarks if any.
iii. May be recommended for approval of Academic Council.
iv. Special remarks if any.

Date: 10/08/2021
Place: Goa University, Taleigao Plateau

Sd/-
Signature of the Dean

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D 3.2 **Minutes of the Board of Studies in International Hospitality Management held on 08th July 2021**

Part A.

i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: **B.Sc. Culinary Arts Annexure-I (Refer Page no 60)**

ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level:

NIL

Part B

i. Scheme of Examinations at undergraduate level:

NIL

ii. Panel of examiners for different examinations at the undergraduate level:

NONE

D 3.1 Minutes of the Board of Studies in Environmental Studies held on 10th August 2021.

Annexurel

M. Sc. / M.A. in Environmental Science

Program structure

Sl. No	Course Code	Course Name	No. of credits
		Common Core courses for M.Sc. / M.A.	
Semester I			
1	ESC-101	Environmental Issues and Perspectives	3
2	ESC-102	Fundamentals of Economics	3
3	ESC-103	Environmental Ethics	3
4	ESC-104	Ecosystems and Biodiversity	3
5	ESC-105	Land, Ocean and Atmospheric Interactions	3
6	ESC-106	Environmental Impact Assessment I	1
Semester II			
7	ESC-201	Ecology and Society	3
8	ESC-202	Climate Change and Sustainability	3
9	ESC-203	Geoinformatics	3
10	ESC-204	Statistics	3
11	ESC-205	Environmental Management	3
12	ESC-206	Environmental Impact Assessment II	1
Semester III			
13	ESC-301	Environmental Impact Assessment III	3
14		Optional Courses	15
Semester IV			
15	ESC-401	Environmental Impact Assessment IV	3
16	ESC-409	EIA Dissertation	8
17		Optional Course	3

Optional Courses:

Sl. No.	Course Code	Optional Science Courses	No. of credits
1	ESO-301	Environmental Chemistry	3

2	ESO-302	Lab Course in Environmental Science	3
3	ESO-303	Green Chemistry	3
4	ESO-304	Geology and Environment	3
5	ESO-305	Marine Pollution	3
6	ESO-306	Conservation Biology	3
7	ESO-307	Environmental Microbiology	3
8	ESO-308	Ecotoxicology	3
9	ESO-309	Environmental Biotechnology	3
10	ESO-310	Water Resource Management	3
11	ESO-311	Disaster Management	3
12	ESO-312	Renewable Energy System	3
13	ESO-313	Marine Biodiversity & Conservation Practices	3
14	ESO-314	Polar Sciences	3
15	ESO-315	Coral Ecology	3
16	ESO-316	Microplastics in Environment	3
17	ESO-317	Marine Plankton Ecology	3
18	ESO-318	Mangrove Ecosystem and Biodiversity	3
19	ESO-319	Water and Wastewater: Monitoring and Treatment Technologies	3
20	ESO-320	Industrial water and wastewater treatment technologies	3
21	ESO-321	Water and Wastewater Analysis	4
22	ESO-322	Occupational Work Environment and Health Hazards	2
		Optional Arts Courses	
23	ESO-351	Environmental Politics	3
24	ESO-352	Environmental Economics	3
25	ESO-353	Environmental History of India	3
26	ESO-354	Women and Environment	3
27	ESO-355	Environmental Security: Dimensions and Perspectives	3
28	ESO-356	Global Environmental Governance	3
29	ESO-357	Global Environmental History	3

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M. Sc. /M.A. in Environmental Science

Syllabi for optional courses of 3rd and 4th Semesters

Title of the Course: Environmental Chemistry

Course Code: ESO-301 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Students should have studied the courses in general science at 10+2 level to understand concepts in environmental chemistry.	
Objective:	1. To introduce fundamentals of environmental chemistry. 2. To provide basic knowledge of environmental pollution, effects of environmental pollutants and control measures. 3. Introduction of various experimental techniques for analysis. 4. Evaluate the utility of various analytical techniques as a qualitative and quantitative tool.	
Content:	**Module 1. Introduction** Environmental segments (Lithosphere, Hydrosphere, Atmosphere, Cryosphere and Biosphere). Biogeochemical cycles (hydrogen, carbon, nitrogen, oxygen, phosphorus, and sulphur). Introduction to Microplastics and Nanoplastics (harmful effects, preventive measures and control measures), E-waste (impact on environment, harmful effects and control measures), and Radioactivity (contamination of radioactivity, radiation hazards, control measures). **Module 2: Air pollution** Air pollutants (primary and secondary), photochemical reaction, Acid rain, Ozone layer depletion, global warming. Carbon monoxide, nitrogen oxides, sulphur dioxide and hydrocarbons (sources, harmful effects, analysis and control measures). Particulate matters (inorganic, organic and radioactive), health hazards, analysis, control devices (Gravitational settlings, particulate air filters, centrifugal separators, wet scrubbers). Case study: Bhopal gas tragedy, London and Los Angeles smog **Module 3: Water pollution** Water analysis (salinity, hardness, pH BOD, COD, colour, turbidity, taste and odour), Water pollutants: nitrates, phosphates, phenols, cyanides, heavy metals (Cd, Hg, Pb, Se, As) and analysis methods. Lake and river water treatment, municipal waste water treatment and industrial effluent treatment (from pesticides, pharmaceutical and electroplating).	06 hours 10 hours 10 hours

	Case study: Kepone, Minamata **Module 4: Soil pollution** Inorganic and organic components in soil, Reactions in soil, waste pollutants in soil. Excess usage of agrochemicals, soil contamination with pollutants. Pesticides (toxicity, biochemical effects and control measures). Waste Management (sources and types of solid wastes, disposal techniques, collection methods, waste management approach). Case study: use of pesticides e.g. DDT	10 hours
Pedagogy:	1. Mainly lectures / tutorials. Seminars/assignments/ presentations/ self-study or a combination of some of these could also be used to some extent. 2. Pre-lab and post-lab assignments or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. De A.K. 2005. Environmental Chemistry, New Age International Publishers, 3rd Edition. New Delhi. 2. Salker A. V. 2017. Environmental Chemistry, Narosa Publishing House, 1st Edition. New Delhi. 3. Sharma B. K. 2003. Environmental Chemistry, GOEL Publishing House, 1st Edition. Meerut. 4. O'Neill P. 2009. Environmental Chemistry, Blackie Academic and Professional, 3rd Edition. London. 5. Khopkar S. M. 2005. *Environmental Pollution Analysis*, New Age International Publishers, 1st Edition. New Delhi.	
Learning Outcomes	1. Students will be in a position to know the basic environmental chemical processes. 2. Students will be able to explain the origin and harmful effects of toxic chemicals in the environment. 3. Student will be in position to use different techniques for qualitative and quantitative estimation of environmental samples.	

Title of the Course: Lab Course in Environmental Science

Course Code: ESO-302 **Number of Credits:** 3

Total Contact Hours: 72 **Effective from AY:** 2022-23

Prerequisites for the course:	Students should have studied the courses in general science at 10+2 level in order to understand some aspects of practicals of environmental science.
Objective:	To introduce students to basic instruments in chemistry lab, significance of calibration of glassware/ use of analytical grade reagents/ general reagents, use of analytical balance, basic laboratory practices, safety in laboratory. To understand the concentration of various pollutants including trace metals in the water/soil/air. The analyses of BOD and COD are used to understand the impact organic pollution on water bodies.

Content:	**Section –I** **Module 1 (Any 6 experiments, 3 hours each)** 1. Demonstration of instruments (colorimeter, pH meter, conductivity meter, Karl Fischer titrator, 2. Calibration of glass electrode and conductivity meter. 3. Determination of pH and conductivity of surface, ground and sea water 4. Determination of alkalinity and acidity of surface, ground and sea water sample using titrimetric analysis. 5. Estimation of total solids, dissolved solids, suspended solids of river/lake/pond water sample. 6. Estimation of total residual chlorine of water samples. 7. Estimation of sulfate in water samples (tap water) by turbidimetry. **Module 2 (Any 6 experiments, 3 hours each)** 1. Determination of pH and conductivity of soil samples. 2. Determination of moisture content of soil samples. 3. Estimation of hardness of water samples by complexometric method 4. Determination of chemical oxygen demand in given water sample 5. Determination of nitrite in water sample using colorimetry. 6. Determination of chromium in water sample by colorimetry. 7. Determination of elements (Fe/Mn/Zn/Pb/Cd etc) in air using high volume sampler **Section –II** **Module -3:** 1. Determination of dissolved oxygen in coastal waters. (4 hrs; Ref.1) 2. Estimation of dissolved oxygen in polluted water (6 hrs. Ref. 2, 3) 3. Determination of biochemical oxygen demand in coastal waters (4 hrs; Ref. 1) 4. Estimation of hydrogen sulfide in coastal waters (4 hrs. Ref. 3) **Module 4:** 1. Determination of chemical oxygen demand in coastal waters by $KMnO_4$ method (4 hrs; Ref. 2) 2. Pre-concentration of sea water by solvent extraction method for analysis of trace metals by AAS (6 hrs; Ref 5,6,7) 3. Estimation of Cu & Pb in coastal waters by AAS method (8 hrs; Ref 5,6,7)	18 hours 18 hours 18 hours 18 hours
Pedagogy:	Pre-lab and post-lab assignments or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	

References/Readings	**Section – I** 1. Sawyer C. N., McCarty P. L. and Parkin G. F. 2002. Chemistry for Environmental Engineering and Science, McGraw-Hill Education. 5th Edition. 2. Dey A. K. 2018. Environmental Chemistry; New Age International Publishers. 9th Edition. 3. Jeffery G.H, Bassett J, Mendham J. and Denney R.C. 1989. Vogel's textbook of quantitative chemical analysis, Longman Scientific & Technical, U.K. 5th Edition. 4. Moore J. W and Moore F. A. 2012. Environmental Chemistry: Academic Press, New Delhi. Academic Press.1st Edition. 5. Lakshmi G.S. 2010. Environmental Science: A Practical Manual, BS Publications.1st Edition. 6. Rattan S. 2011. Experimental in applied Chemistry, S.K. Kataria and Sons. 3rd Edition. 7. Mitra S., Patnaik P. and Kebbekus B. 2019. Environmental chemical analysis: Laboratory Experiments in Environmental Chemistry, CRC Press.2nd Edition. 8. Henrie S.A. 2015. Green Chemistry: Laboratory manual for General Chemistry, CRC Press Taylor & Francis Group.1st Edition. **Section – II** 1. Martin, D.F. 1972. Marine chemistry. Vol. 1, Academic Press, London. 2. Standard methods for the examination of water and waste water analysis. 22nd Edition. 3. Rice E.W. and Bridgewater L. 2012. American Public health association, Washington DC. 4. Grasskhoff, Ehrdardt K.M. and Krembling K. 1983. Methods of Seawater analysis, Verlag Chemie, Weinneim. 5. Strickland J.D.H and Parsons T.R. 1972. A practical hand book of seawater analysis. Fisheries Board of Canada bulletin. 2nd Edition. 6. Riley J.P. and Skirrow G. 1975. Analytical chemistry of seawater. In Chemical Oceanography. Vol. 3. Academic Press, London. 7. Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby C. and Roberts J.D. 1976. (eds) Chapman S. B. Chemical Analysis. In: Methods in plant Ecology. Blackwell Scientific Publications, Oxford, Chapter 8.	

Learning Outcomes	1. Students will be in a position to know the basic environmental chemical processes. 2. Students will be able to explain the origin and harmful effects of toxic chemicals in the environment. 3. Student will be in position to use different techniques for qualitative and quantitative estimation of environmental samples. 4. The results of analyses of different pollutants in sea water can be used to set the limits of their discharge. 5. These concentrations will be compared with the daily intake of, or exposure to a pollutant by organism/man and it can lead to acceptable concentration of pollutant in organism. 6. These studies would help to regulate the release of a particular pollutant in the marine environment.	

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Title of the Course: Green Chemistry

Course Code: ESO-303 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Students should have studied the courses in general science at 10+2 level so as to understand the basic concepts in green chemistry and related aspects.	
Objectives:	1. To learn basic knowledge and principles involved in green chemistry and create awareness of greener chemistry. 2. To understand energy saving and making green processes in chemical reactions. 3. To develop social concern for waste generated from various processes.	
Content:	**Module 1: Introduction to Green Chemistry (***Ref. 1,3)* Need for Green Chemistry; Overview of twelve green chemistry principles as proposed by Paul Anastas and John Warner; Explanation with examples under each principle. Introduction to sustainable development; Why regulation is required to achieve sustainable development; Environmental policy and innovation; Future trends and challenges in sustainable development. **Module 2: Designing Greener Approaches and Waste Handling** *(Ref. 1, 4)* Safer designs for the target molecule, Minimization, Simplification, Substitution, Moderation, Limitations, Replacement of Toxic Reagents, Use of Alternative Solvents (suitable examples in each case). Problems caused by waste; Sources of waste from the chemical	06 hours 10 hours

	industry; Waste minimization techniques; On-site waste treatment; physical treatment; Chemical treatment; Biotreatment; Degradation; Rules for degradation; Polymer recycling **Module 3: Future Trends in Green Chemistry and Chemicals from Renewable Raw Materials** *(Ref. 2, 5)* Introduction to solid acid catalysts and their significance in industrial applications; phase-transfer catalysis, Biocatalysis: basic principles, enzyme catalysed reactions, Photocatalysis: Introduction and significance with examples. Renewable Raw Materials: Carbohydrates, Ethanol, Lactic acid, Indigo-natural colour, Riboflavin, Ascorbic acid, Fats and oils, Biodiesel, Fatty acid esters, Terpenes and green polymers **Module 4: Alternative energy sources for greener processes** *(Ref. 1)* Design for energy efficiency; Photochemical reactions; Advantages of and challenges faced by photochemical processes; Examples of photochemical reactions; Chemistry using microwaves; Microwave heating; Microwave-assisted reactions; Sonochemistry; Electrochemical synthesis.	10 hours 10 hours
Pedagogy:	Mainly lectures / tutorials, seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
References/ Readings	1. Lancaster M. 2002. Green Chemistry-An Introductory Text, Royal Society of Chemistry, 1st Edition. 2. Sheldon R.A., Arends I., and Hanefeld U. 2007. Green Chemistry and Catalysis, WILEY-VCH, 1st Edition. 3. Afonso C.A.M. and Crespo J. G. 2005. Green Separation Processes: Fundamentals and Applications, WILEY-VCH, 1st Edition. 4. Matlack S. 2001. Introduction to Green Chemistry, Marcel Dekker, Inc. 1st Edition. 5. Ahluwalia V.K. and Kidwai M. 2004. New Trends in Green Chemistry, Anamaya Publishers, 1st Edition.	
Learning Outcomes	1. Student should be in position to understand and apply the basic principles of Green chemistry in daily life. 2. Students should understand control measures of waste. 3. Students will be able to understand the green Industrial processes.	

Title of the Course: Geology and Environment

Course Code: ESO-304 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Bachelor's degree of this University or an examination of any other University recognised as equivalent.	
Objective:	1. To understand the interaction of humans with the geological environment. 2. To study pollutants in the environment and to find the suitable remedial measures to cover harmful effects. 3. To impart knowledge about different natural as well as manmade hazards with deterrent measures.	
Content:	**Module 1: Introduction** Earth in space and time, Internal structure of the Earth, Geological evolution of earth: plate tectonics and seafloor spreading, Geological time scale, Life on Earth, Human and geological environment	06 hours
	Module 2: Mineral resources, environmental problems and management • Mineral resources and reserves; UNFC. • Mining: surface and underground mining, mine ventilation, mine drainage, environmental effect of mining, environmentally sensitive green mining, mine closure. • Trace elements and their implications on health.	10 hours
	Module 3: Pollution and environment • Hydrology and pollution – Impact assessment of degradation and contamination of surface water and groundwater quality due to industrialization and urbanization; remedial measures. • Soil Science - Soil profile, soil types and their classification and formation; soil quality degradation, control measures • Waste and its disposal - surface and subsurface disposal of toxic, metallic and radioactive wastes. Planning and management of hazardous waste. Domestic refuse and landfill.	10 hours
	Module 4: Natural and manmade hazards Assessing geological hazards and risks: Earthquakes, volcanic eruptions, floods and droughts, mass movement-landslides, rock fall, preventive and mitigation measures.	10 hours
Pedagogy:	Lectures, case studies, discussions and assignments.	
References/ Readings	1. Merrits D., de Wet A. and Menking K. 1997. Environmental Geology: an Earth System Science Approach. W. H. Freeman, New York. 2. Keller E.A. 2012. Introduction to Environmental Geology. 5th	

	Edition. 3. Montgomery C.W. 2010. Environmental geology. Professor Emerita, Northern Illinois University. 9th Edition. 4. Montgomery C.W. 2020. Environmental geology. Professor Emerita, Northern Illinois University. 11th Edition. 5. Pipkin B.W., Trent D.D., Hazlett R., and Bierman P. 2013. Geology and the Environment. Cengage Learning. 6. Valdiya K.S. 1987. Environmental geology, Indian context. Tata McGraw-Hill Pub. Co. 7. Valdiya K.S. 2013. Environmental Geology: Ecology, Resource and Hazard Management. McGraw-Hill Education.	
Learning Outcomes	In this course a student will learn about: 1. Concepts of environmental geology and its interaction with the human beings, 2. Management of geological resources, 3. Appropriate use of the geological site for waste disposal, and 4. Recognition of natural hazards and mitigation.	

Title of the Course: Marine Pollution

Course Code: ESO-305 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level	
Objective:	1. To identify the type of materials added to the sea and their sources. 2. What effect these additions to the sea and animal living there. 3. What implications these effects have for human health and 4. What is being done to reduce the undesirable effects.	
Content:	**Module 1: Introduction** Introduction to Environment, Objectives of environment, Marine pollution definition, Some questions, Categories of additions, Nature of inputs, and Sources of inputs. Gross chemical composition of seawater, Sources of dissolved and particulate matter in the sea, Geochemical balance and residence times of elements in seawater **Module 2: Organic wastes** Biochemical oxygen demand, the dilution factor, Settlement, Oxygen budget, Consequences of organic discharges into Thames and Mersey estuaries. Decomposition of organic matter in oxic and anoxic environments. Sewage and sewage treatment, Disposal of sewage sludge, Industrial wastes and treatment processes with reference to wastes from paper and pulp and soap manufacturing industries. Oil spills and Consequences of oil	06 hours 10 hours

	pollution: Introduction, Inputs, major accidental spills, fate of spilled oil at sea and Treatment of spilled oil. **Module 3: Conservative pollutants** Conservative pollutants: Measures of contamination, Toxicity, Acute, Chromic exposure and Detoxication. Trace metal pollution in coastal waters (Hg, Cd, Pb, Cu and Fe), and Radioactive pollution: Sources, classification, effects of radiation, MPD concept, protection and control from radiation, Beneficial aspects of radiation and Disposal of royal wastes. Halogenated hydrocarbons; Low molecular weight compounds, High molecular weight compounds, Inputs to sea, fate in the sea, Biological effects, environmental impact, mode of poisoning of pesticides. **Module 4: Pollution indicators, marine corrosion and Assessment of pollution damage** Pollution indicators: Criteria for selection of indicator organism, Quantification of pollution load, basic pre requisites, Response to different pollution load and Time integration capacity. Macro algae and Mollusc as indicators to monitor trace metal pollution in coastal waters. Monitoring strategies of Marine pollution: Critical pathway approach and Mass balance approach. Marine corrosion: Definition, Corrosion theory, Effects, classification, factors affecting corrosion of metal in seawater and control of marine corrosion. Standards in water quality and instrumental techniques, Pollution status of the North Sea. Present status of coastal pollution in India and Future strategies. Assessment of pollution damage: The need, serious ness of damage and assessment of damage.	10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study	
References/ Readings	1. Riley J.P and Skirrow G. (eds.) 1975. Chemical Oceanography Vol: 3. Academic press, New York. 2. Goldberg, E.D. 1976. The health of the oceans, UNESCO Press. 3. Clark R.B. 1986. Marine Pollution, Oxford science Publications. 4. Phillips J.D.H. 1980. Quantitative aquatic biological indicators, Applied Science Publishers. 5. Sharma B.K. and Kaur H. 1994. Thermal and radioactive pollution. Krishna Prakasham Mandir, Meerut. 6. Sharma B.K. and Kaur H. 1994. Water Pollution, Krishna Prakasham Mandir, Meerut. 7. Chandler K.A. 1985. Marine and offshore corrosion, Butter Worths, London.	

Learning Outcomes	1. The course helps in understanding the impact of various pollutants on marine ecosystem; it analyses the factors responsible for degradation and suggests suitable corrective measures. 2. To create awareness among students, and to safeguard the marine environment 3. The course suggests policy measures to prevent marine pollution and to create sustainable marine environment and 4. To provide advisory and technical service to government and industry for pollution abatement.	

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Title of the Course: Conservation Biology

Course Code: ESO-306 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduation in any discipline from a recognised University	
Objective:	1. To systematically understand biodiversity at global, regional and local level; threat assessment, management of biodiversity and restoration of ecosystems. 2. To appreciate the need of biodiversity conservation in the context of various developmental pathways and policy framework.	
Content:	**Module 1: Introduction** Introduction to conservation biology and biodiversity at global, regional and local levels; flagship species, umbrella species, keystone species, IUCN Red list of threatened species, endemic species, Scheduled species and their distribution. Valuing Biodiversity: ecological economics and direct use values, indirect use value, ethical values. Threats to biodiversity and human-wildlife conflicts. **Module 2: Diversity of Megadiversity Countries** Flora and fauna of Hotspots and Megadiversity Countries (United States of America, Mexico, Colombia, Ecuador, Peru, Venezuela, Brazil, Democratic Republic of Congo, South Africa, Madagascar, India, Malaysia, Indonesia, Philippines, Papua New Guinea, China, and Australia.) **Module 3: In-situ and Ex-situ conservation** Threat assessment and management, Conservation at population and species levels; in situ conservation of migratory species across borders. Biodiversity monitoring, establishing, designing and managing protected areas; national parks, wildlife sanctuaries, biospheres,	06 hours 10 hours 10 hours

	sacred groove, marine protected areas, conservation outside the protected areas, conservation in Indian culture, case studies on efforts for conservation of Indian flora and fauna. Ex situ conservation, captive breeding, microbial conservation, plant propagation (tissue culture), reestablishment and relocation, conservation of plant diversity in seed banks, germplasm reserves. **Module 4: Sustainable development, Restoration and Legislation** Sustainable development at Local, National and International levels. Restoration of damaged ecosystem, endangered species restoration with advanced technologies, applied population biology, manipulation of wild population, establishing new populations, control of predators, herbivores and competitors. National and International conservation organisations and Institutions. Environmental policies, environmental law and legislations.	10 hours
Pedagogy:	Use of conventional, online and ICT methods. Field visit, case study/ field work/project/self-study. Lecture/tutorials/assignments.	
References/ Readings	1. Balmford A. et al. 2012. What conservationists need to know about farming. Proc. Roy. Soc. B 279: 2714-2724. 2. Hunter M.L., Gibbs J.B. and Sterling E.J. 2008. Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing. 3. Milner-Gulland E.J. and Rowcliffe J.M. 2007. Conservation and Sustainable Use: A Handbook of Techniques. Oxford University Press. 4. Sodhi N.S. and Ehrlich P.R. (Eds.) 2010. Conservation Biology for All. Oxford University Press. 5. Pandit M.K. et al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163. 6. Primack R.B. 2002. Essentials of Conservation biology. Sinauer Associates, Sunderland, USA. 7. Pullin A.S. 2002. Conservation Biology, Cambridge University Press. 8. Stachowicz J.J. and Tilman D. 2005. Species invasions and the relationships between species diversity, community saturation and ecosystem function. In Species Invasions, Insights into Ecology, Evolution and Biogeography (Sax, D.F. et al. eds.), Sinauer Associates, Sunderland, MA. 9. Wheeler T. and Von Braun J. 2013. Climate change impacts on global food security. Science 341: 508-513. Woodroffe R., Thirgood S. and Rabinowitz A. 2005. People and	

	Wildlife, Conflict or Co-existence? Cambridge University.	
Learning Outcomes	1. To know the value of global biodiversity. 2. Understand threat to biodiversity, threat assessment and management plans to conserve biodiversity. 3. Plan restoration of the damaged ecosystem using advanced technology.	

Title of the Course: Environmental Microbiology

Course Code: ESO-307 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+2 level.	
Objective:	This course develops concepts in Environmental Microbiology: Microbial diversity in different habitats and role of microorganisms in biogeochemical cycles. Microbial remediation of pollutants and microorganisms in sustainable development.	
Content:	**Module 1: Introduction** Origin of life & 3 domains of life. Introduction to microbial world and brief history of microbiology. Microbes from diverse environments**:** Hypersaline, hydrothermal vent, sulphur springs, polar environments, Soda Lake, marine environments, deep sub surfaces, oligotrophic, deserts, garden/field soil, fresh water lakes.	06 hours
	Module 2: • **Studies on microbial diversity and methods to study microbial communities:** Metabolic diversity of microbial communities. • **Role of microorganisms in biogeochemical processes:** Biogeochemical cycling of carbon, nitrogen, sulphur, iron and phosphorus; Functional diversity of microbial communities. Role of microorganisms in ecological succession; Microbial symbiotic associations; Biofilms.	10 hours
	Module 3: Environmental microbiology in sustainable development Microorganisms in agriculture: Mycorrhizae, biofertilizers, composting, biocontrol agents, organic farming; Microorganisms for food security and clean energy; Microorganisms for bioremediation of oil spills, heavy metals, xenobiotics and waste water treatment.	10 hours
	Module 4: Impacts of microorganisms on environment and humans: Microbiomics; Microorganisms and climate change; Climate change and occurrence of diseases; Disease causing microorganisms and antibiotics; Algal blooms and harmful algal	10 hours

	blooms; Ballast water and significance of invasive microorganisms.	
Pedagogy:	Lectures/tutorials/assignments/online teaching /powerPoint presentations/MOODLE, case study.	
References/ Readings	1. Willey J.M., Sherwood L.M. and Woolverton C.J. 2017. Prescott's Microbiology. McGraw-hill Education. 10th Edition. 2. Medigan M.T., Bender K.S., Bukley D.H., Sattley W.M. and Stahl D.A. 2019. Brock Biology of Microorganisms. Pearson. 15th Edition. 3. Munn C. 2020. Marine Microbiology: Ecology and applications. Garland science, 3rd Edition. 4. Naik M.M. and Dubey S.K. 2017. Marine pollution and Microbial remediation. Springer. 5. Satyanarayana T., Johri B. and Anil T. 2012. Microorganisms in Environmental Management, Springer. 6. King R.B., Sheldon J.K. and Long G.M. 2019. Practical Environmental Bioremediation: The Field Guide, CRC Press. 2nd Edition. 7. Meena S.M. and Naik M.M. 2019. Advances in Biological Science Research: a practical approach. Elsevier. 8. Bertrand J.C. and Coumette P. 2015. Environmental Microbiology: Fundamentals and Applications. Springer. 9. Yates M., Nakatsu C.H., Miller R.V. and Pillai S.D. 2016. Manual of Environmental Microbiology, ASM press, 4th Edition. 10. Cavicchioli et al. 2019. Scientists' warning to humanity: microorganisms and climate change. Nature reviews microbiology. 17: 569-586. Dirk H. 2018. The Gut microbiome in health and disease. Springer.	
Learning Outcomes	On successful completion, course participants will be able to understand: 1. Distribution of microbes in diverse environment and their role. 2. Significance of microorganisms in biogeochemical cycling. 3. Natural bioremediation processes and sustainable development.	

Title of the Course: **Ecotoxicology**

Course Code: ESO-308 **Number of Credits**: 02

Total Contact Hours: 24 **Effective from AY**: 2022-23

Prerequisites for course:	Students are required to have a basic knowledge of biology and Environmental science. Graduate of any discipline.
Objective:	Students will gain full understanding of the effects of toxic substances on ecosystems and their living components. Students will also gain knowledge on the various organisms and methods used in ecotoxicological testing as well as mitigation

Content:	**Module 1: Introduction to Ecotoxicology** Important concepts of ecotoxicology, Routes by which pollutants enter ecosystems; Major classes of pollutants, their sources and ecotoxicological effects, permissible levels of toxicants in the environment	06 hours
	Module 2: Concepts of toxicology Acute and chronic toxicity**,** dose response, bioaccumulation**,** biomagnification**,** bioavailability**,** biodegradation; Toxicokinetics: Absorption, Distribution, Metabolism, Biotransformation and Elimination of Toxicants, Physiological and biochemical effects of toxic substances: Genotoxic, neurotoxic compounds, endocrine disruptors; Effects at the molecular level, cellular level, organism level (physiological, reproduction, behaviour).	06 hours
	Module 3: Biomonitoring Ecotoxicity tests (lab-based and field tests) in air, water and soil, Use of model organisms for ecotoxicology: fish, helminthes, molluscs, mice, Environmental Risk Assessment Environmental bioindicators of ecotoxicity with faunistic studies.	06 hours
	Module 4: Microbial Ecotoxicology and Biotechnology for mitigating environmental toxicity Interaction between microorganisms and pollutants; Role of microorganisms in detoxification and degradation of environmental pollutants, Metagenomic techniques to study microbial diversity in polluted environment Ameliorating nutrient toxicity (Nitrates and Phosphates), Handling sludge toxicity, Microbial and Phytoremediation (wetlands), Treatment of domestic wastewater using wetlands – a case study	06 hours
Pedagogy	In class/online lectures, assignments, group activities, presentations	
Reading / Reference	1. Walker C. H., Sibly R. M., Hopkin S. P. and Peakall D.B. 2012. Principles of ecotoxicology. 4th Edition. CRC Press, Taylor and Francis. 2. Jorgensen S. E. 2010. Ecotoxicology: A derivative of encyclopedia of ecology. Academic Press. 3. Moriarty F. 1999. Ecotoxicology: The study of pollutants in ecosystems. 3rd Edition. Academic Press. 4. Peakall D. 2012. Animal biomarkers as pollution indicators. Chapman and Hall. 5. Hayes W. A. 2014. Principles and methods of toxicology. CRC Press, Taylor and Francis. 6. Naik M. M. and Dubey S. K. 2017. Marine pollution and Microbial remediation. Springer. 7. Cravo-Laureau C., Cagnon C., Duran R. and Lauga B. 2017. Microbial ecotoxicology. Springer	

	8. Scragg A. 2005. Environmental biotechnology. Oxford University Press	
Learning Outcomes	On successful completion, students will be able to: 1. Understand the toxic effects of pollutants in ecosystems 2. Apply concepts of ecotoxicology using model organisms and for assessing environmental risk 3. Understand mitigation strategies using micro-organisms	

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Title of the Course: Environmental Biotechnology

Course Code: ESO-309 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level.	
Objective:	This course will impart knowledge on biotechnological applications that can be used to tackle environmental issues emerging due to industrialization and globalization.	
Content:	**Module 1: Introduction** Environment, Biotechnology, Concepts in Environmental Biotechnology. Areas of environmental biotechnology. Development, use and regulation of biological systems for remediation of contaminated environments (land, air, water), and for environment-friendly processes (green manufacturing technologies and sustainable development). Ethical issues in environmental biotechnology. **Module 2:** • **Biotechnology in agriculture and environmental sustainability** Biotechnology innovations for global food security [(Genetic engineering (GE)/recombinant DNA technology (rDNA) and transgenic organisms for biological pest, weed and disease control)]; Modern plant breeding methods for increasing crop productivity and improve soil structure. Case studies - Bt cotton, Bt Brinjal, Golden Rice. Blue revolution (ocean based economy) and Sea-agriculture; Seaweed, Fish, Shrimp and Bi-valve farming. Modern marine biotechnology for the sustainable food production. Macroalgal	06 hours 10 hours

	biorefinery for supply of resources (food or feed ingredients, chemicals, bioenergy and materials). • **Monitoring environmental pollution** Robust techniques and innovative new concepts for identifying and screening of toxins and pathogens in the environment (genetic and biochemical kits and reagents, CRISPR–Cas technology, and cellular models). **Module 3: Biotechnology in Waste handling, treatment and sustainable development** (Environmental biotechnology and human health)**:** Centralized wastewater treatment systems (primary, secondary and tertiary treatment); Decentralized wastewater treatment systems (phytoremediation in constructed wetland system, waste stabilization ponds, anaerobic digesters). Solid waste management, Plastic pollution, Rendering plastic degradation in marine environment. Genetic engineering for combating environmental pollution, bioremediation. Waste to energy power plants, recycling, reducing waste and composting & vermicomposting. Novel composting methods for sludge biomass (such as *terra preta* of the sludge); Resource recovery for sustainable development (recovery of N & P, energy, organics and clean water). **Module 4:** • **Resource management and environment conservation** Basic concept of saving of resources and energy through biotechnology; Prevention of eutrophication using macroalgae; biological control of mosquitos. • **Bioresource technology for clean environment** Biomass (wood waste, agricultural waste, municipal solid waste, manufacturing waste, and Sewage sludge) as source of energy and bio-fuels. Microalgae as a source for Biodiesel. Biodegradable plastic.	10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/ online/self-study	
References/Readings	1. Scragg A. 1999. Environmental biotechnology, Pearson Education Limited, UK. 2. Rehm H. J. and Reed G. 1999. Biotechnology- a comprehensive treatise, VCH Verleg, Germany. 3. Chaterjee A. K. 2000. Introduction to environmental biotechnology, PHI, India.	

	4. Colin M. Marine microbiology: ecology and applications. Second edition. Garland science. 5. Satyanarayana T., Johri B. and Anil T., Microorganisms in environmental management, Springer Publishers. 6. King R. B., Sheldon J. K. and Long G. M. Practical environmental bioremediation: the field guide, Lewis Publishers. 7. Meena S. M. and Naik M. M. Advances in biological science research: a practical approach. Elsevier. 8. Willey J. M., Sherwood L. M., Woolverton C. J. and Prescott S. Microbiology. 10th Edition. 9. Prabhu M. 2016. Resource recovery from wastewaters for sustainable development. Ph. D. Thesis. BITS Pilani Goa. Shodhganga.URL: http://hdl.handle.net/10603/124726. 10. Prabhu M., Israel A., Palatnik R. R., Zilberman D. and Golberg A. (2020). Integrated biorefinery process for sustainable fractionation of *Ulva ohnoi* (Chlorophyta): process optimization and revenue analysis. Journal of Applied Phycology. 32, pp. 2271–2282. 11. Zollmann M., Robin A., Prabhu M., Polikovsky M., Gillis A., Greiserman S. and Golberg A. 2019. Green Ttechnology in green macroalgae biorefinery. Phycologia, 58 (5), 516–534.	
Learning Outcomes	At the end of this course, students will be able to apply their knowledge for the application of biotechnological processes for betterment of environment and sustainable development of the society.	

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Title of the Course: Water Resource Management

Course Code: ESO-310 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level	
Objective:	1. To understand occurrence and circulation of water in nature. 2. To study the functioning, problems and measures that can be taken for sustainable development of water resource.	
Content:	**Module 1: Introduction** Traditional methods of water management, agriculture, sanitization systems and environment. Hydrological cycle: Evaporation, evapotranspiration, precipitation, runoff and infiltration.	06 hours

	Module 2: Aquifers characteristics and irrigation Classification of aquifers and confining layers, hydraulic properties of aquifers, water table and piezometric surface. Availability of water in Lakes, ponds, streams and rivers. Irrigation in India: Water control and crop production. Construction, technology and operation of water control system. Problems related to overexploitation and groundwater mining. Saline water intrusion in coastal aquifers and its control. Fresh-salt water interface. **Module 3: River flooding and rain water harvesting** Nature, extent, magnitude and frequency of floods, urbanization and flooding. Impact of climate change on water availability. Concept of basin management, basin investigation. Subsurface investigation of groundwater. Drilling methods, construction, development and maintenance of wells. Rainwater harvesting and water conservation techniques and its importance. Concept of artificial recharge: methods, wastewater recharge for reuse. **Module 4: Pollution and Water governing laws** Pollution of surface and groundwater: Municipal sources, industrial sources, agricultural sources. Case studies of water pollution in India. Physical, chemical, biological properties of water. Quality criteria for different uses. Water Governance: Salient features of The Water (Prevention and control of pollution) Act, 1974 and Goa water (Prevention and Control of Pollution) Rules, 1988.	10 hours 10 hours 10 hours
Pedagogy:	Lectures / Assignments / Seminars/ Self-study	
References/Readings	1. Fetter C. W. 2018. Applied hydrogeology. Waveland Press. 2. Grafton R. Q. & Hussey K. (Eds.). 2011. Water resources planning and management. Cambridge University Press. 3. Jain S. K., Pushpendra K. A., and Vijay P. S. 2007. Hydrology and water resources of India. Vol. 57. Springer Science & Business Media. 4. Johnson W. 1982. Environmental Geology-Coates, *DR.* 5. Keller E. A. 2007. Introduction to environmental geology. Prentice-Hall, Inc. 6. Kumar R., Singh, R. D. & Sharma K. D. 2005. Water resources of India. Current science, 794-811. 7. Pennington K. L. & Cech T. V. 2009. Introduction to water resources and environmental issues. Cambridge University Press. Fetter, C.W.: Applied hydrogeology, NY, Macmillon.	

	8. Todd D. K. & Mays L. W. 2004. Groundwater hydrology. John Wiley & Sons. 9. Vaidyanathan A. 1999. Water resource management: institutions and irrigation development in India. Oxford University Press.	
Learning Outcomes	The main outcome of the course is to understand and develop information with respect to occurrence and circulation of water in nature and find solutions to the water related problems.	

Title of the Course: Disaster Management

Course Code: ESO-311 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022–23

Prerequisites for the course:	Bachelor's Degree of this University or an examination of any other University recognized as equivalent.	
Objective:	To provide basic conceptual understanding of disasters, understand approaches of Disaster Management and build skills to respond to disasters	
Content:	**Module 1: Introduction** Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management Natural and Man-made disasters, Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters – The Refugee Problem	06 hours
	Module 2: Types, Trends, Causes, Consequences and Control of Disasters Geological Disasters (earthquakes, volcanic eruptions, landslides, tsunami, land subsidence); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire); and Anthropogenic Disasters (building collapse, mining mishaps, rural and urban fire, road and rail accidents, oil spills, nuclear, radiological, industrial, chemicals and biological disasters, terrorism)	10 hours
	Module 3: Disaster Management Cycle and Framework, and Applications of Science and Technology to Disaster Management Disaster Management Cycle and the Paradigm Shift in Disaster Management. Pre-Disaster – Risk Assessment and Analysis, Risk Mapping,	10 hours

	zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation, Disaster Communication, Search and Rescue, Emergency Operation Centre, Incident Command System, Relief and Rehabilitation Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure, Early Recovery, Reconstruction and Redevelopment Geo-informatics in Disaster Management (RS, GIS, GPS) Disaster Communication System (Early Warning and Its Dissemination) Land Use Planning and Development Regulations Disaster Safe Designs and Constructions Structural and Non Structural Mitigation of Disasters S&T Institutions for Disaster Management in India **Module 4: International Organisations, NGOs, best practices and Disaster Management in India** International organisations: Red Cross, Sphere, Oxfam, World Relief, CBM International, UNDRO, UNDDR Yokohama Strategy, Hyogo Framework of Action, UNISDR Critical analysis of NGO experience. Community Based Disaster Risk Reduction (CBDRR) Disaster Profile of India – Mega Disasters of India and Lessons Learnt Disaster Management Act 2005 – Institutional and Financial Mechanism National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter-Governmental Agencies	10 hours
Pedagogy	Lectures/ tutorials/ assignments/ self-study	
References/ Readings	1. Coppola D.P. 2007. Introduction to international disaster management. Elsevier Science (B/H), London. 2. Gupta M.C. Manual on natural disaster management in India. NIDM, New Delhi. 3. Lopez-Carresi A., Fordham M., Wisner B., Kelman I. and Gaillard Jc. 2014. Disaster management: International lessons in risk reduction, response and recovery. Routledge. Pp. 352. 4. World Disasters Report, 2009–2020. International Federation	

	of Red Cross and Red Crescent, Switzerland. 5. Goyal S. L. 2006. Encyclopaedia of disaster management. Vol I, II and III, Deep & Deep, New Delhi. 6. Gunn A. M. 2008. Encyclopaedia of disasters – environmental catastrophes and human tragedies. Vol. 1 & 2. Greenwood Press. 7. Kapur A., et al. 2005. Disasters in India studies of grim reality. Rawat Publishers, Jaipur. Pp. 283. 8. Srivastava H.N. and Gupta G.D. 2006. Management of natural disasters in developing countries. Daya Publishers, Delhi. Pp. 201. 9. Alexander D. 1999. Natural disasters. Kluwer Academic London. Pp. 632. 10. Disaster Management Act, 2005. Govt. of India, New Delhi. 11. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management. 12. Rubin C. B. and Cutter S.L. 2020. U.S. Emergency management in the 21st Century from disaster to catastrophe. Routledge. Pp. 290. 13. UNISDR. 2002. Natural disasters and sustainable development: Understanding the links between development, environment and natural disasters. Background Paper No. 5. 14. Disaster Management Guidelines, GOI-UN Disaster Risk Program (2009–2020) 15. Gupta A.K., Niar S.S and Chatterjee S. 2013. Disaster management and risk reduction, role of environmental knowledge. Narosa Publishing House, Delhi. 16. Modh S. 2010.Managing natural disasters. Mac Millan publishers India Ltd. Disaster Preparedness Kit, American Red Cross.	
Learning Outcomes	Students will acquire a comprehensive understanding of disasters and the field of disaster management, so that they understand, analyse and evaluate the relationship of disasters with development, vulnerability and environmental factors.	

Title of the Course: Renewable Energy System

Course Code: ESO-312 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements	
Objective:	This course develops to understand the concept of energy and its form. Various form of energy, its conversation to electric form and relevant systems and energy management.	
Content:	**Module 1: Introduction**	06 hours

	Classification of Energy Energy chain and common forms of usable energy, Present energy scenario, World energy status-Energy scenario in India, Introduction to renewable energy resources: Solar, Wind, Hydro Power and Nuclear Energy. **Module 2: Solar Energy Harvesting Systems** • *Solar Energy and Systems* Introduction to Solar Energy-Energy from sun-Spectral distribution of Solar radiation- Instruments for measurement of solar radiation-Solar radiation data analysis. Thermal applications -Introduction to Solar thermal collectors- Types - Principle of operation of different collectors - Flat plate- Evacuated tube collectors-Compound parabolic collectors- Solar air heaters - Solar dryers-solar cookers- solar stills - Solar ponds - concentrating collectors- line type - point type - Methods of Solar power generation - Power towers • *Solar Photovoltaics Cells* Physics of solar cells - Cell and module , Manufacturing Process: Characteristics of cells and module - Performance parameters - BoS- PV System applications - Standalone- Grid connected systems. **Module 3: Alternative Energy Harvesting Systems** • *Small Hydro Power, Ocean and Geothermal Energy Systems, Wind Energy* Introduction - types - system components, discharge curve and estimation of power potential - Turbines for SHP; Power generation through OTEC systems - various types - Energy through waves and tides - Energy generation through geothermal systems – types ; Resource assessment - types of wind turbines - selection of components - blade materials - power regulation - various methods of control - wind farms - site selection - off shore wind farms - Solar Wind Hybrid energy systems. • *Electric Vehicles and its roadmap* Electric Vehicles, Batteries design material, resources, specifications and EV roadmap.	10 hours 10 hours

	Module 4: Energy Management • *Energy Management* Transmission of Energy System AC and DC Forms, Relevant issues in Transmission and Transmission lines, Engine Efficiency, Low power designs and managements, E-Waste, Worldwide Scenario and Indian Context, Rules and Regulations.	10 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Andrews J. and Jelley N. 2013. Energy science: principles, technologies and impacts, Oxford Universities press. 2. Fang L. Y. and Hong Y. 2012. Renewable energy systems, advanced conversion technologies and applications, CRC Press. 3. Wolfson R. 2011. Energy, environment, and climate, Publisher: W. W. Norton &Company; 2nd Edition. 4. Hodgson P. E. 2010. Energy, the environment and climate change, Publisher: Imperial College Press. 5. Boyle G. 2012. Renewable energy, power for a sustainable future, Oxford University Press. 6. Jha A. R. 2010. Wind turbine technology, CRC Press 7. Duffie J. A. and Beckman W. A. 2013. Solar engineering of thermal processes, Wiley 8. Solanki C. S. 2011. Solar photovoltaics, fundamentals, technologies and applications, Prentice Hall India. 9. Global climate change reports. 10. TERI Energy Data Year Books 11. Bureau of Energy Efficiency- Volume 1	
Learning Outcomes	1. Correlate various form of energy and World energy status and various conversion system. 2. Define opportunities available for energy conservation and for use of renewable energy resources in local and regional entities.	

Title of the Course: Marine Biodiversity and Conservation
Course Code: ESO-313 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the Course:	Graduates in any discipline with science subjects at the 10+2 level.	
Objective:	Addresses basic concepts of marine biodiversity at all levels, IPR, life patenting, values and its implications on the environment and human life with respect to the anthropogenic inputs.	
Content:	**Module 1: Introduction** Biodiversity, definition, concept, types; Biodiversity measurements - taxic, phylo-genetic and molecular approaches. **Module 2: Genetic variance and dynamics**	06 hours

	Intra-specific Genetic variance and factors affecting, biodiversity and intra-specific variations, dominance and over-dominance hypothesis, adaptive polymorphism, genetic variations, loss and increase dynamics of biological diversity, conceptual models, hypothesis proposed in deep sea biodiversity. **Module 3: Ecological processes and ecosystem stability** Marine Biodiversity and ecosystem functions, competition, predation and heterogeneity as biodiversity determinants; ecosystem approach, functions and keystone species, engineer organisms, diversity-stability, rivet, drivers and passenger, idiosyncratic hypothesis, co-operative relations, top down and bottom up theories, cascade effects and fishing through the food webs. **Module 4: IPR and biodiversity conservation** Biodiversity and Intellectual Property Rights (IPR) and bio-piracy, life patenting and implications, impact of GATT/WTO on farmer's right, indigenous, traditional knowledge. Biodiversity conservation - Biological diversity Act, sanctuaries, marine parks, protected areas, hotspots and marine biosphere reserves of India	10 hours 10 hours 10 hours
Pedagogy:	Lectures / tutorials / assignments / self-study	
References/Readings	1. Routledge H.K. 2014. Marine Biodiversity Conservation: A practical approach. Pp. 318. 2. Queiroga H., Cunha M.R., Cunha A., Moreira Q.V., Rodrigues A.M., Serodio J. and Warwick R.M. 2007. Marine biodiversity: Patterns, processes, assessment, threats, management conservation. Springer Science and Business Media. Pp. 353. 3. Ormond R.F.G., Gage J.D. and Angel M.V. (Eds.) 1997. Marine biodiversity - Pattern and Processes. Cambridge University Press. Pp. 449. 4. Kumar A. and Nangia S.B. 2004. Biodiversity and Environment. A.P.H. Publication Corporation, New Delhi. Pp. 659. 5. Shiva V. (Eds.) 1994. Biodiversity Conservation. Indian National Trust for Art and Cultural Heritage, New Delhi. Pp. 315.	
Learning Outcomes	The students will be able to understand holistic view of the marine biodiversity with emphasis on ecosystem functions, IPR, life patenting and conservation policies.	

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Title of the Course: Polar Sciences

Course Code: ESO-314 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Basics understanding of marine sciences, marine microbiology and biotechnology	
Objective:	Lectures provide basic information about physical geographic conditions of the Arctic and Antarctic, history of discovery and colonization of these regions. The course also includes assessing the significance of the Polar Regions in context of atmospheric circulation, energy exchange, circulation in the Southern Ocean, cryosphere, biota and its sensitivity to global changes. Lectures are an integral part of information on current trends in polar research, development of tourism and its potential impacts, protection of natural resources and polar ecosystems.	
Content:	**Module 1: Introduction** • Delimitation of Arctic and Antarctic, their basic differences, discovering, exploitation and scientific utilizability. • Astronomic factors and their reflexion in polar regions.	06 hours
	Module 2: Ecology of Polar region • Climate of polar regions - energy balance of the ground surface, water balance, baric field and atmospheric circulation, air temperature and air humidity, precipitation. Climate change and climate variation and their consequences i.e. polar regions (glacials and interglacials and their influence on the hydrosphere, geosphere, cryosphere and biosphere). • Freshwater hydrology and oceanology. Surface water and ground water. Polar oceans - submarine relief, systems of sea curents, water substitution with the lower latitudes and its energy consequences	10 hours 10 hours
	Module 3: Glaciology • Glaciology of polar regions - reasons of glaciation and its development, glaciation of continents and of sea surface, ice mass balance. Cryosphere as a stabilizer of Earth climate. • Development of earth surface in polar regions, glacial and periglacial geomorphologic processes - permafrost and its energy roots, regional structure, active layer of permafrost, frost weathering, slope dynamics. Soil in polar regions.	10 hours
	Module 4: Flora and Fauna	

	• Vegetation in polar regions - limiting by abiotic factors (microclimate, nutrients, water), soil flora, space structure of polar vegetation (subpolar, polar, polar deserts and semideserts, polar wetlands). Origin of polar (alpine) plants, vascular plants and their adaptation and acclimatization on the polar environment. Cryptogams in polar regions. • Stress physiology of polar plants. • Fauna of polar regions - invertebrates, evolution and space structure, physiological adaptation on polar conditions, nutrient succession. • Microbial diversity Anthropogenic impacts on polar ecosystems - heat pollution of planetary geosystem, changes in chemical composition of atmosphere and their consequences (global transport of pollutants, anthropogenic change in greenhouse effect, ozone depletion and its consequences), changes in biodiversity.	
Pedagogy:	Online/offline lectures, tutorials, assignments and visit to research laboratory	
References/Readings	1. Holdgate M. W. 1970. Antarctic Ecology. Academic Press, London, New York. 2. King J. C. & Turner J. 1997. Antarctic meteorology and climatology. 1st publ. Cambridge: Cambridge University Press. xi, 409. 3. Oke T. R. Bounrady layer climates, Routledge, London and New York, 435. 4. Przybylk R. 2003. The climate of the Arctic. Dordrecht: Kluwer Academic Publishers. xi, 270. 5. Richard S. and Per M. 2006. Buffalo a complete guide to Arctic wildlife. N.Y.: Firefly Books. 464 6. Stonehouse B. 1989. Polar ecology. Blackie, Glasgow – London. 7. Thurman H. V. & Alan P. T. 2005. Oceánografie: [tajemný svět moří a oceánů]. Translated by Adam Petrusek. Vyd. 1. Praha: Computer Press, viii, 479. Warwick F., Johanna V. and Parry, L. 2008. Polar lakes and rivers: limnology of Arctic and Antarctic aquatic ecosystems. 1st pub. Oxford: Oxford University Press, xviii, 327.	
Learning Outcomes	Polar ecosystems are comparatively simple from point of view of their internal structure. On the other hand they exist as a result of long development whose effect is perfect adaptation of their biotic component to the extremal living conditions. It enables their existence on the bounds of energy, climate and food requirement. Polar ecosystems were form under influence of	

	specific astronomic, geographical, oceanographic, atmospheric and geochemical factors. They have influenced their inanimate components (georelief and its substratum, atmosphere, hydrosphere, kryosphere, pedosphere) and subsequently biosphere. Nevertheless, arised ecosystems impact backward as a complex the whole planet - notably from the energetic point of view. Its reflexion is first of all global change of ocean water, global climate and consequently complicated cascade of processes, which form the development of shape of Earth surface and development of the biosphere.	

Title of the Course: Coral Ecology

Course Code: ESO-315 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduate of any science discipline	
Objective:	1. To understand the reef formation, distribution and biological/ecological processes of coral reefs. 2. To explore the coral biome and its ecological interactions 3. To study the threats, climate change adversities and restoration of coral habitats.	
Content:	**Module 1: Introduction** • **Coral reef distribution and significance** Types of coral reefs and their global distribution with special emphasis to Indian waters. Salient features of the ecosystem: Habitat characteristics, reef biodiversity and nursery grounds, interactions with seagrass ecosystem and migratory corridors, natural barriers. Economic Importance: Fisheries and marine products, tourism and recreational activities. **Module 2: Coral evolution and community interactions** • **Coral evolution and development** Paleoecology of corals. Theories of evolution: Subsidence theory, Glacial Control Theory, Stand Still Theory, Cycle of Erosion theory. Coral reef formation, morphology and functional zones, Ocean chemistry and aragonite saturation. Hydrodynamics and lagoon circulation. • **Coral biome dynamics** Coral communities and trophic structure: Primary producers, consumers, food webs, productivity in coral reefs.	06 hours 10 hours

	Symbiotic associations: Algal-coral associations, bacterial symbiosis, multi-partner symbiosis. Internal nutrient cycling, Energy transfer/trophodynamics, Adaptive bleaching hypothesis, Coral probiotic hypothesis, Rosenberg's hologenome hypothesis. **Module 3: Threats to Coral Ecosystem** • **Physico-chemical and biological factors influencing coral reefs** Environmental factors (pH, temperature, salinity, sedimentation, waves, ocean currents, weather, nutrients, aerial exposure, light) and their impact. Competitors, Microbial infections, predators, parasites • **Anthropogenic threats** Tourism and its impact, pollution, overfishing, habitat destruction. Global warming, thermal bleaching, ocean acidification, sea level rise and its effect on coral health. **Module 4: Coral disease spread assessment and prophylactic measures** Coral disease survey and monitoring protocols. Disease response plan and outbreak management. Ex-situ treatment measures: Use of antibiotics, anti-oxidants and Phage therapy. Cultivation and conservation of corals: Coral Restoration and Health Consortium (CRHC), Global Coral Reef Conservation Project, Resilient Reef Initiative Project, Mithapur Coral Reef Recovery Project. Traits of climate change resilient clades. Laws and policies for conservation and management of corals in Indian seas/waters.	10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study/case-studies	
References/ Readings	1. Sheppard C., Davy S., Pilling G. and Graham N. 2018. The biology of coral reefs, 2nd Edition. Oxford University Press. Doi: 10.1093/oso/9780198787341.001.0001 2. Dubinsky Z. and Stambler N. 2011. Coral reefs: an ecosystem in transition, 1st Edition. Springer, Dordrecht. Doi: 10.1007/978-94-007-0114-4 3. van Oppen M. J. H and Blackal L. L. 2019. Coral microbiome dynamics, functions and design in a changing world. Nature Reviews Microbiology. Doi: 10.1038/ s41579-019-0223-4 4. van Oppen M. J. H. et al. 2015. Building coral reef resilience through assisted evolution. PNAS. Doi: 10.1073/pnas.1422301112	

	5. Harvell C. D. et al. 2007. Coral disease, environmental drivers, and the balance between coral and microbial associates. Oceanography. Doi: 10.5670/oceanog.2007.91 6. Raymundo L. J., Couch C. S. and Harvell C. D. Coral disease handbook guidelines for assessment, monitoring & management. 7. Chakravarti L. J. and van Oppen M. J. H. 2018. Experimental evolution in coral photosymbionts as a tool to increase thermal tolerance. Frontiers in Marine Science. doi: 10.3389/fmars.2018.00227 8. Ainsworth T. D. et al. 2007. Coral disease diagnostics: what's between a plague and a band? Applied and Environmental Microbiology. doi:10.1128/AEM.02172-06 9. Contardi M. et al. 2020. Treatment of coral wounds by combining an antiseptic bilayer film and an injectable antioxidant biopolymer. Scientific Reports. Doi:10.1038/s41598-020-57980-1	
Learning Outcomes	1. The coral ecosystem function and its ecological and economic implications. 2. Awareness of impact of anthropogenic activities on coral health 3. Conservation and management strategies of damaged corals and their recovery.	

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Title of the Course: Microplastics in Environment

Course Code: ESO-316 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level	
Course objectives	This course introduces to the concept of microplastics as a pollutant and its impact on the environment and human.	
Content:	**Module 1: Introduction to Microplastics** Introduction to Plastics and microplastics: Types of plastics: PET, HDPE, PVC, LDPE, PP, PS, Other; and microplastics types: fibres, microbeads, fragments, nurdles, foam. Primary and Secondary, microplastics and its formation. **Module 2: Distribution of Microplastics** Global occurrence, sources of microplastics. Distribution and fate of plastic in the environment.	06 hours 10 hours

	Microplastics pollution in Land, Water- Freshwater and Marine waters, Air, Snow. : *Impacts of Microplastics* Potential impacts on the environment and human health. Microplastics as carriers of trace and heavy metals and its role as pollutant. Microplastic in plants, animals and humans. **Module 4: Sampling, characterization, mitigation of Microplastics and case studies** • **Sampling and characterization** Methods used for sampling, quantification of microplastics. Instrument for identification of microplastics- FTIR and Raman Spectroscopy. • **Mitigation** Mitigation methods for microplastics and role of Blue Flag certification- international eco-level tag Foundation for Environmental Education. G20 and United Nations Environment Assembly resolution on marine litter and microplastics. • **Case studies** Microplastics pollution studies in India-Case studies with special reference to Goa.	10 hours 10 hours
Pedagogy:	Since it is a theory course, to get a strong understanding of the subject, case studies will be discussed and seminar topics other than from the syllabus will be given to students.	
References/ Readings:	10. Crawford C. B. and Quinn B. 2016. Microplastic pollutants. 1st Edition. Elsevier Science. 11. Rocha-Santos T., Costa M., Mouneyrac C. 2022. Handbook of microplastics in the environment. Springer 12. Rocha-Santos Teresa A. P. and Duarte A.C. (eds.). 2017. Characterization and Analysis of Microplastics. Vol 75. Elsevier.	
Learning Outcomes	1. The course helps in understanding the formation of microplastics and its impact on environment. 2. The course will help in creating awareness among student about microplastic pollution and will help them to reflect upon mitigation of such problems.	

Title of the Course: Marine Plankton Ecology

Course Code: ESO-317 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at the 10+ 2 level.	
Objective:	1. To describe the role of plankton in marine ecosystem function. 2. To understand the effects of environmental factors on plankton biogeography and their role in food web dynamics.	
Content:	**Module 1: Introduction** Marine environment zonation, Coastal and Open Ocean, Significance of oceans and its biodiversity to humans Significance of planktonic biota to the health of oceans Distribution of plankton in the Tree of Life Major groups of phytoplankton, zooplankton, picoplankton, virioplankton (viruses) their biology and significance **Module 2: Plankton Diversity and Trophic dynamics** Phytoplankton: Diatoms, Dinoflagellates, Haptophytes (coccolithophores, prymnesiophytes), Prasinophytes Zooplankton (Holoplankton, Meroplankton): Chaetognaths, Cnidarians, Molluscs, Radiolarians, Foraminiferans, Crustaceans, Larvaceans Multiple marine protistan lineages in seven supergroups of eukaryotic tree of life Factors affecting primary production: light, nutrients, mixed layer depth, chelating agents, tides, turbulence, grazing, Mixotrophy Interactions within and across trophic levels (allelopathic interactions) Planktonic Food Web structure and trophic transfer efficiency, Marine microbial food webs, microbial loop, viral shunt **Module 3: Plankton in Marine Ecosystem Functioning** Phytoplankton C:N:P ratios, stoichiometric plasticity, phenotypic plasticity, Contribution to biogeochemical cycles, Carbon Sequestration, Biological Carbon Pump Ecological success of diatoms, Blooms, Diatom/Dinoflagellate Index as an indicator for ecosystem change Harmful Algal Blooms (HABs) and biotoxins, morphological and physiological characteristics of HAB species, HAB dynamics Implications of Climate change on plankton (global warming, ocean acidification)	06 hours 10 hours 10 hours 10 hours

	Module 4: Quantitative Observations of Planktonic Ecosystems Techniques and instruments used in plankton studies: Advances in Automated Technology to observe and measure plankton, Pigment composition, Optical and Acoustical methods e.g. Optical Plankton Counter, Zooglider Quantitative Imaging Devices e.g. Flow Cytometry, FlowCAM, FlowCytoBot Molecular Phylogenetic Approaches, High throughput 'omics' data Monitoring plankton in oceans through various international projects: Continuous Plankton Recorder (CPR), Global Alliance of CPR Surveys (GACS), The Scientific Committee on Oceanic Research (SCOR), Global Ocean Observing System (GOOS), Global Ocean Ecosystem Dynamics (GLOBEC), Integrated Marine Biosphere Research (IMBeR), TARA Oceans, GEOHAB	
Pedagogy:	Lectures/tutorials/assignments/self-study/Moodle/Videos	
References/ Readings	1. Morrissey J.F., Sumich J.L. and Pinkard-Meier D.R. (Eds.) 2018. Introduction to the biology of marine life. 11th Ed. Jones & Bartlett Learning. 2. Sardet C. and Rosengarten R.D. (Eds.) 2015. Plankton: wonders of the drifting world. The University of Chicago Press. 3. Lalli C.M. and Parsons T.R. (Eds.) 2010. Biological oceanography: an introduction. 2nd Ed. Elsevier, Amsterdam. 4. Nybakken J.W. and Bertness M.D. (Eds.) Marine Biology: an ecological approach. San Francisco Pearson Education. 5. Mitra A., Banerjee K. and Gangopadhyay A. (Eds.) 2004. Introduction to marine plankton. Delhi Daya Publishing House. 6. Parsons T.R. (Ed) 1990. Biological oceanographic processes. Oxford Pergamon Press. 7. Raymont J.E.G. (Ed) 1980 Plankton and productivity in the oceans: Phytoplankton. Oxford Pergamon Press. 8. Levinton J.S. (Ed) 2011. Marine biology: Function, biodiversity, ecology. New York Oxford University Press. 9. Ormond R. (Ed) 1997. Marine biodiversity: Patterns and processes. Cambridge University Press. 10. Reynolds C.S. (Ed) 2006. The ecology of phytoplankton. Cambridge University Press. 11. Jungblut S., Liebich V. and Bode M. (Eds) 2018. YOUMARES 8	

	– Oceans across boundaries: Learning from each other. SpringerOpen.	
Learning Outcomes	Students will be able to understand ecosystem processes such as grazing, productivity, and the relative importance of plankton to marine food webs and biogeochemical cycling, and also monitoring work carried out globally.	

Title of the Course: Mangrove Ecosystem and Biodiversity

Course Code: ESO-318 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Graduates in any discipline with science subjects at 10+2 level.	
Objective:	To introduce the students to the dynamic mangrove ecosystem, its composition – abiotic and biotic, benefits, threats and need for conservation.	
Content	**Module 1: Introduction** Mangroves, global distribution, current status, threats, ecology and environment, relation with other ecosystems, uses of mangroves	06 hours
	Module 2: Structure and function of mangrove ecosystem 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**	10 hours
	Module 3: 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 on Sunderban Anthropogenic destruction - deforestation, landfills, land reclamation, waste disposal sites, pollution – water quality and persistent chemicals**,** loss of mangrove biodiversity	10 hours
	Module 4: Restoration and conservation Restoration and afforestation projects, ecosystem based	10 hours

	management, protected areas, restoration tools, monitoring methods – remote sensing and GIS, awareness programmes, training programmes, community based management, role of institutions, NGOs, global conservation strategies, economic valuation (cost benefit analysis), national and global mangrove conservation policies, conservation and mangrove protection laws, international agreements – Ramsar convention, case study – mangroves of Goa	
Pedagogy:	Lectures/ case studies/ tutorials/ videos/ assignments/ self-study/ visits	
References/ Readings	1. Kathiresan K. and Ajmal Khan S. 2005. UNU-INWEH-UNESCO International training course on Coastal Biodiversity in Mangrove Ecosystem- Course manual, Annamalai University, India. Pp. 410. 2. FAO 2007. The world's mangroves: 1980–2005. FAO, Rome, Italy. 3. Sandilyan S. and Kathiresan K. 2012. Mangrove conservation: a global perspective. Biodiversity Conservation, 21, 3523–3542. 4. Nagelkerken I., Blaber S.J.M. and 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. and 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. Shinnaka T., Sano M., Ikejima K., Tongnunui P., Horinouchi M. and Kurokura, H. 2007. Effects of mangrove deforestation on fish assemblage at Pak Phanang Bay, Southern Thailand. Fisheries Science, 73, 862–870. 7. 1st International Training Course on Mangrove Ecosystems in the Western Indian Ocean Region December 2-9, 2013 Mombasa, Kenya. UNU-INWEH-UNESCO. 8. Singh V.P. and Odaki K. 2004. Mangrove ecosystem: structure and function. Scientific Publishers, Jodhpur, India.	
Learning Outcomes	1. Students will gain knowledge about mangrove ecosystem, its floral and faunal biodiversity. 2. Imprint the importance of mangroves in maintaining the global climate and balance in the nutritional as well as biogeochemical cycles. 3. Highlight the need to conserve and protect the mangroves.	

Title of the Course: Water and Wastewater: Monitoring and Treatment Technologies
Course Code: ESO-319 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements	
Objective:	1. Understand the water quality criteria and Standards of water for domestic, industry and agriculture consumption. 2. Learn the causes and effects of water pollution and quality deterioration. 3. Learn the principles and instrumentation for water quality control and monitoring. 4. Motivate students for designing innovative methodologies in monitoring and treatment of water and wastewater.	
Content:	**Module 1: Introduction** • **Water balance and benchmarks**: Earths water budget, Hydrological cycle, Demand -supply situation and global benchmarks for major water dependent Industries • **Water quality**: water quality standards, Standards for Package Drinking water and mineral water, Water quality standards and parameters (ISI-BIS and USPH), Water pollution: Sources and types of water pollution, Causes and impacts on Environment • **Water pollutants**: Organic (Pesticides, oil spill, tar balls and toxic organic chemicals, antibiotics), Inorganic, Sediments, Marine, Radioactive, Eutrophication, trace and heavy elements in water, Bioindicators. **Module 2: Water and wastewater analysis** • **Water and wastewater**: Characteristics, Classification of wastewater • **Sampling techniques**: Separation scheme for organic compounds in water. Preservation techniques for sample. • **Monitoring techniques and methodology**: Physical, Chemical and biological analysis of water and wastewater parameters such as pH, Conductance, Turbidity, Temperature, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), TKN, Dissolved Oxygen (DO), Acidity and Alkalinity, Ammonia, Chlorides, Fluoride, Nitrate and Nitrite, Cyanide, sulphide, Sulphate, Phosphate, Total Hardness, Boron, Silica, Metal and Metalloids, Heavy metals and other pollutants, Chemical	06 hours 10 hours

	Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). **Module 3: Water treatment** • **Treatment of water:** Conventional and modern methods of treatment, Flowchart of the Water Treatment Plant, Treatment Methods (Theory and Design). • **Treatment processes**: Screening, Oil Separation, Sedimentation, Coagulation-Flocculation, Settling tanks, Aeration and Gas transfer, Precipitation, Softening, Filtration-Sand, Charcoal, Multimedia etc., Reverse Osmosis technology, Membrane processes, Ultra filtration. Disinfection System: chemical based and other disinfection methods such as Chlorination, Ozonation, UV, Adsorption and Ion exchange, Electrochemical and other methods. **Module 4: Biological treatment** • **Types of treatment processes**: attached and submerged, aerobic and anaerobic, facultative etc., • **Aerobic processes**: Activated Sludge Process and various modified processes, SBR, MBR, UA-SBR, FAB etc, Oxidation ponds and Rotating Biological Contactors • **Anaerobic Processes**: Up flow Anaerobic Sludge Blanket, Anaerobic digesters, Anaerobic filters. • **Sludge treatment**: Preliminary operation, thickening, conditioning, Dewatering, Filtration, Digesting and Drying of sludge, Sludge disposal • **Modular Sewage Treatment Plant:** Water reuse and recycling (Industry / Site visit for Water treatment plant and STP)	10 hours 10 hours
Pedagogy:	Lectures/case studies /workshops/industrial visit /documentaries and discussion/ research article analysis /mini projects / survey or mapping projects.	
References/Readings	1. De A.K. 2019. Environmental Chemistry. New Age International Publishers. 9th Edition. 2. Bennett M.R. and Doyle P. 2016. Environmental Geology. In, Geology and the Human Environment. Wiley India Pvt. Ltd. 3. Pipkin B.W. and Trent D.D. Geology and the environment. 3rd Edition. ISBN 0-534-51383-2 4. Patwardhan A.D. Industrial Wastewater Treatment. 2ndEdition, Eastern Economy Edition. 5. Karia G. L. and Christian R.A. Wastewater Treatment: Concepts	

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and Design Approach, Eastern Economy Edition.
6. Bratby J. 2006. Coagulation and flocculation in water and wastewater treatment. 2nd Edition. IWA Publishing, London, UK.
7. Grady C. P. L. Jr., Daigger G.T. and Lim H.C. 1999. Biological wastewater treatment. 2nd Edition. Marcel Dekker, Inc., New York.
8. Abbasi S.A. 1998. Environmental pollution and its control. Cogent, Pondicherry.
9. Abbasi S.A. 1998. Water Quality Sampling and Analysis. Discovery, New Delhi.
10. Aery N.C. 2016. Manual of environmental analysis. Ane Books, New Delhi.
11. Ahluwalia V. K. 2008. Environmental Chemistry. 2nd Edition. Ane, New Delhi.

Additional reading material:
1. Chand A. 1989. Environmental pollution and protection. 1st Edition. H.K. Publishers, New Delhi.
2. Droste R.L. and Gehr R.L. 2018. Theory and practice of water and wastewater treatment. 2nd Edition.
3. Kumar R. and Singh R.N. Municipal water and wastewater treatment. Environmental Engineering Series. ISBN: 9788179931882
4. Lal B. and Sarma P.M. Wealth from waste: trends and technologies. 3rd Edition. TERI press.
5. Lin S.D. 2014. Water and wastewater calculation manual. McGraw-Hill Education. ISBN: 9780071819817
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<td>Learning Outcomes</td>
<td>After successful completion of the course student will be able to:
1. Explain the causes and effects of water pollution.
2. Analyse the water as per BIS and international standards.
3. Identify suitable technologies for the treatment of water and wastewater.
4. Design the water and wastewater treatment plants.
5. Operate, maintain and manage treatment plants.
6. Start own enterprise.</td>
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Title of the Course: Industrial water and wastewater treatment technologies

Course Code: ESO-320 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements	
Objective:	1. Elaborate the latest development in wastewater treatment technologies 2. Explain the sources and effects of water pollution from various industries 3. Understand the principles and processes in wastewater treatment technologies 4. Identify suitable technologies for wastewater treatment	
Content:	**Module 1: Introduction** Types of industrial pollutants, Industrial wastewater characterisation, Categorisation of industries- green, orange and red industries, Standards of industrial waste disposal, Minimum National Standards (MINAS) and Goa State Regulatory Framework for effluents and trade waste.	06 hours
	Module 2: Industrial wastewater treatment • **Methods of industrial waste treatment**: Primary, secondary and tertiary/polishing treatment such as equalisation, neutralisation, precipitation. • **Physico-chemical and biological treatment processes**: Sedimentation, Oil separation, Floatation, Coagulation, Filtration, Ion exchange membranes. • **Biological oxidation** - Removal of organics (Sorption, Stripping, biodegradation), Unit operations and electromechanical equipment used in the treatment processes.	10 hours 10 hours
	Module 3: Advance wastewater treatment • **Advance wastewater treatment process** – Removal of specific pollutants – nitrification, denitritation/Anammox process, SHARON-ANAMMOX process for treatment of ammonium rich wastewater, Biological Phosphate Removal (BPR). • **Membrane processes** – Fundamentals, Membranes – Types, classifications, Microfiltration, Ultrafiltration, Nanofiltration and reverse osmosis, Electrodialysis, Ion exchange. • **Advance oxidation process**: Photocatalysis, Ozonation – Ozone / UV, Ozone / Hydrogen peroxide, Hydrogen peroxide/ UV applications and other significant proven technologies.	10 hours

	Module 4: Common Effluent Treatment Plant (CETP) & Decentralised Wastewater Treatment (DWT) • **CETP and DWT**: Requirement and objectives Planning and management of CETP and DWT, facilities for small scale industries • **Energy recovery from wastewater**: Microbial fuel cells, microbial electrolysis cell, microbial desalination cell, biohydrogen production and combination of technologies.	
Pedagogy:	Lectures/ video/ Powerpoint presentation/ Industrial visit / documentaries and discussion / research article analysis / mini projects / survey and mapping projects	
References/Readings	**Reference books:** 1. De A.K. 2019. Environmental Chemistry. New Age International Publishers. 9th Edition. 2. Bennett M.R. and Doyle P. 2016. Environmental Geology. In, Geology and the Human Environment.Wiley India Pvt. Ltd. 3. Patwardhan A.D. Industrial Wastewater Treatment. 2ndEdition, Eastern Economy Edition. 4. Karia G. L. and Christian R.A. Wastewater Treatment: Concepts and Design Approach, Eastern Economy Edition. 5. Bratby J. 2006. Coagulation and flocculation in water and wastewater treatment. 2nd Edition. IWA Publishing, London, UK. 6. Grady C. P. L. Jr., Daigger G.T. and Lim H.C. 1999. Biological wastewater treatment. 2nd Edition. Marcel Dekker, Inc., New York. 7. Abbasi S.A. 1998. Environmental pollution and its control. Cogent, Pondicherry. 8. Abbasi S.A. 1998. Water Quality Sampling and Analysis. Discovery, New Delhi. **Additional reading material:** 1. Aery N.C. 2016. Manual of environmental analysis. Ane Books, New Delhi. 2. Droste R.L. and Gehr R.L. 2018. Theory and practice of water and wastewater treatment. 2nd Edition. 3. Kumar R. and Singh R.N. Municipal water and wastewater treatment. Environmental Engineering Series. ISBN: 9788179931882 4. Lal B. and Sarma P.M. Wealth from waste: trends and technologies. 3rd Edition. TERI press. 5. Lin S.D. 2014. Water and wastewater calculation manual.	

	McGraw-Hill Education. ISBN: 9780071819817 6. Asiwal R.S., Sar S.K., Singh S., Sahu M. 2016. Waste water treatment by effluent treatment plants. SSRG International Journal of Civil Engineering, 3, 12.	
Learning Outcomes	After successful completion of the course student will be able to: 1. Explain different pollutants from various industries. 2. Suggest suitable technologies for the wastewater treatments depending on type of pollutants. 3. Design the suitable process for wastewater treatment plants. 4. Manage and supervise the maintenance of treatment plants. 5. Adopt the principle of reduce, recycle and reuse in industries.	

Title of the Course: Water and Wastewater Analysis

Course Code: ESO-321 **Number of Credits:** 04

Total Contact Hours: 96 **Effective from AY:** 2022-23

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements	
Objective:	Develop analytical skills of the students for water and wastewater analysis useful in wastewater and industrial treatment plants	
Content:	**Part I** • **List of the experiments (6 hour duration)** 1. Determination of pH, conductivity and Turbidity of water and wastewater samples (pH meter, conductometer, and nephelometer) 2. Determination of dissolved oxygen and total hardness of water (Ca and Mg) of water and wastewater sample. 3. Determination of BOD of wastewater samples. 4. Determination of COD of wastewater samples. 5. Determination of TSS and TDS of a given water sample. 6. Determination of Chromium in given water sample using UV-VIS spectrophotometer. 7. Determination of the metal ions (Na and K) using Flame photometer (Including working, standardization and plotting of calibration curve). 8. Estimation of Metals and metalloids (spectrophotometry / AAS). • **A visit to ETP / STP and report writing (8 hours)** **Part 2 : Waste water from industrial effluents (6 hours each)**	48 hours 48 hours

	1. Estimation of ammonia from wastewater samples (Nessler's Method) 2. Nitrate and nitrite using spectrophotometric method 3. Determination of fluoride using spectrophotometer 4. Determination of phosphates in wastewater using spectrophotometric method 5. Estimation of total cyanide in wastewater using titrimetry and spectrophotometric method 6. Estimation of tannin and lignin and surfactants from Wastewater 7. Estimation of pesticides in water sample using GC 8. Determination of *E. coli* and total bacteria in wastewater	
References/ Readings	1. Kanwaljit Kaur, Handbook of Water and wastewater Analysis , Atlantic , Edition (January 2007) 2. S.K. Maiti , Handbook of Methods in Environmental Studies : Water and Wastewater Analysis, Oxford Book Company , May 2011 , ISBN-10 9380179871 3. Beenish Saba, Laboratory Skills in Water and Wastewater Analysis , VDM Verlag , 2011 edition , ASIN 3639371984 4. Anil k De , Environmental Chemistry , New Age International Publications, 9th Edition , ISBN-10 9789387477247	
Learning Outcomes	After successful completion of the course student will be able to: 1. Carry out analysis of wastewater and evaluate the results. 2. Design various experiments for reducing the environmental pollution. 3. Provide innovative solutions for the treatment of wastewater and recycling. 4. Analyze industrial effluent for water quality parameters and submit report to various agencies.	

Title of the Course: Occupational Work Environment and Health Hazards

Course Code: ESO-322 **Number of Credits:** 02

Total Contact Hours: 24 **Effective from AY:** 2022-23

Prerequisites for the course:	There is no prerequisite for this course apart from the program requirements
Objective:	1. Recognize and evaluate occupational safety and health hazards at workplace. 2. Determine appropriate hazard controls and hierarchy of controls. 3. Analyze the effects of workplace exposures, injuries, illness, fatalities and methods to prevent incidents using effective health and safety management systems.

Content:	**Module 1: Introduction** • **Occupational hazards**- Physical, chemical, biological and ergonomics hazards. • **Occupational diseases**- Pneumoconiosis- silicosis, Anthracosis, Byssinosis, Bagassosis, Farmer's lung, Lead poisoning, Occupational cancer, Occupational dermatitis, Radiation hazards, sick building syndrome. **Module 2: Occupational hazards of agricultural workers** Common occupational Hazards: Somatic diseases, accidents, toxic hazards, physical hazards, respiratory diseases, accidents in industry, sickness, absenteeism, health problems due to industrialization. Measures for health protection of workers: Prevention of occupational diseases, medical measures, engineering measures. Human health problems due to pollution , public health programs. Food poisoning- Types of food poisoning, prevention and control, indicators of health. **Module 3: Occupational health hazards and public health legislation** Evaluation and control of occupational health hazards; Occupational health surveillance, Control programmes in the context of Indian Factories Act- case studies. Epidemiology and public health- Principles of epidemiology, epidemiology and control of diseases caused by important microbes in water, air, milk and soil. The factories Act. 1948. Industrial safety standards and regulations. Accidents – definitions - prevention and control. Safety management system- concepts of safety management systems- EMS ISO 18000 and ISO 22000 series. OSHA- Law & regulations. Public liability insurance act, Mining act.	06 hours 08 hours 10 hours
Pedagogy:	Lectures/case studies /workshops/industrial visit /documentaries and discussion/ research article analysis	
References/Readings	1. The occupational safety, health and working conditions code. 2020. Professional Book Publishers. ASIN: B08LB7GRFS 2. Raj T.R. 2013. Elements of industrial hazards: health, safety, environment and loss prevention. Taylor and Francis Publications. 3. Reese C.D. 2015. Occupational health and safety management: a practical approach. CRC Press. 3rd Edition. ISBN 978-1482231335 4. Stranks J. 2006. The health and safety handbook (A practical guide to health and safety law, management policies and procedures). ISBN: 978-0749449001, ASIN: 0749449004 5. Yates W.D. Safety professional's reference and study guide. CRC	

	Press publications. ISBN:978-1138892972	
Learning Outcomes	After completing the course student will be able to: 1. Evaluate workplace to determine the existence of occupational safety and health hazards. 2. Identify relevant regulatory and national standards benchmarking with best practices in industry. 3. Select appropriate control methodologies based on the hierarchy of the controls. 4. Analyze injury and illness data for trends.	

Title of the Course: Environmental Politics

Course Code: ESO-351 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Bachelor's in any discipline	
Objective:	1. The course seeks to discuss the manner in which politics shapes the discourse on environment at various levels. 2. It shall address how actors and institutions of politics impinge on decision making and outcomes in addressing environmental problems of the day. 3. While doing this it tries to expose the students to issues of power, contestation and cooperation that often emerge at local, national as well as international environmental domain.	
Content:	**Module 1: Introduction** Concept of Power, Conflict and Interests in relation to Environment, Green Political Theory, Green Political Parties **Module 2: State and environmental politics** State as repository of Power and Authority, Regulation, State as an agency of Development, **Module 3: Non-state actors and environmental politics** Non-Governmental Organizations as Pressure Groups/advocates/partners in environmental change, Conflict with State and Corporations. **Module 4: Multilateral institutions and environmental regimes** International and Regional Organizations relating to Environment, Multilateral Institutions as sites of international negotiations, goal setting and accountability.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study/case-studies	
References/ Readings	1. John B. 1999. Rethinking Green Politics Nature, Virtue and Progress, Sage Publishers. 2. Schumacher E.F. 1993. Small Is Beautiful: A Study of	

	Economics as if People Mattered, RHUK Publishers 3. Guha R. 2016. Environmentalism: A Global History, Penguin Random House. India. 4. Gareth P. 1995. Global Environmental Politics: Second Edition (Dilemmas in World Politics), Westview Press 5. Neil C. 2012. The Politics of the Environment: Ideas, Activism and Policy, Cambridge University Press. 6. Duit A. et al., 2014. State and Environment – The Comparative Study of Environmental Governance, MIT Press. 7. Newell P. 2006. Climate for Change: Non-State Actors and the Global Politics of the Greenhouse, Cambridge University Press. 8. Schiele S. 2014. International environmental regimes and their treaties, Cambridge University Press. 9. Gupta S.S. 2016. Caring for Nature: The River of life (The Story of the Narmada Bachao Andolan), The Energy and Resources Institute. 10. Khanna D.R., Kumar P. and Singh V. 2013. Ecology of the Tehri Dam, Biotech Books. 11. Kutting G. and Herman K. 2018. Global Environmental Politics: Concepts, Theories and Case Studies, Taylor and Francis.	
Learning Outcomes	1. The student should be able to relate environment with the larger context of politics that often emerges out of it. 2. He/She would be able to look at not only the key environmental issues at stake, but also how various actors both state and non state influence the same through both cooperation and discord. 3. The course would thus enable the student to get a grasp of how the institutions, politics and policy intersect in the domain of environment.	

Title of the Course: Environmental Economics

Course Code: ESO-352 **No. of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisite for course:	Any introductory course in economics
Objective:	This course aims to equip the learner with tools of resource allocation using basic concepts in Economics. This will include market and non-market based approaches to understanding problems of global and local pollution and challenges to sustainability using techniques of environmental valuation.

Content:	**Module 1: Environment & economy** Environmental Economics and Ecological Economics. A Framework for Ecological Perspective, Inter-linkages and Trade-offs, Poverty, Environment and Development debate. India's status and policies on SDGs and NDCs, Environmental Kuznets Curve **Module 2: Theory of externalities & environmental policy** Missing Markets, Non-convexity, Non-linearity, Public Goods, Common Property Resources, Coase Theorem and Issues in Property Rights; Pigouvian Taxes, Subsidies, Tradable Permits, Price v/s Quantity tools **Module 3: Sustainable development** Renewable and Non-renewable Resources - Optimal Use under different market Structures. Strong and Weak Sustainability; Global agreements, Economics of Ecosystems and Biodiversity. Issues of Climate Change Adaptation and Mitigation. **Module 4: Issues in valuation** Costs and Benefits. Use Values, Non-use Values, Option Values, Discount Rates. Methods of Valuation: Revealed and Stated preferences; Market and Non-Market valuation; Applications of valuation in developing countries.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	In class/online lectures, assignments, group activities, presentations.	
References/Readings	1. Kolstad C. 2012. Intermediate Environmental Economics. Oxford University Press. 2. Harris J.M. and Roach B. 2021. Environmental and Natural Resource Economics: A Contemporary Approach Routledge. 3. Perman R., Ma Y., Common M., Maddison D. and McGilvray J. 2011. Natural Resource and Environmental Economics, Addison Wesley. 4th Edition. 4. Tietenberg T. 2000. Environmental and Natural Resource Economics, Addison-Wesley. 5th Edition. 5. Conrad J.M. and Rondeau D. 2020. Natural Resource Economics: Analysis, Theory, and Applications. Cambridge University Press.	
Learning Outcomes	On successful completion, course participants will be able to: 1. Understand how the environmental resources affect human welfare. 2. Have an informed opinion on environment-development trade-offs. 3. Assess international challenges of sustainability.	

Title of the Course: Environmental History of India
Course Code: ESO-353 **Number of Credits:** 03
Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	It is required that the student be interested in the subject of history, and be ready to put in sincere efforts to acquire knowledge in this area.	
Objective:	1. To cover in a systematic, comprehensive and critical way the nature, issues, problems and movements related to environmental history in India. 2. To enable the students to comprehend the urgent need for environmental conservation, and appreciate the policy of sustainable development. 3. To encourage an interdisciplinary approach to environmental history. To inculcate the spirit of environmental ethics.	
Content:	**Module 1: Introduction** Definition of Environmental History –Historiography - Sources. **Module 2: Man and Nature in Pre-Modern India** Hunter-Gatherer Societies to Agricultural Societies – the Eclectic Belief Systems and Cultural Ecology – Sacred Groves. **Module 3: Environmental Change and Conflict in Modern India** Colonial Interests on Forests, Forest Acts (1865, 1878 and 1927) and Policies – Systematic Conservation vs. Exploitation Debate – Issue of Shifting Cultivation - Settled Cultivators and the State – Decline of Artisanal Industry – Deforestation – Protests Against the British Forest Acts and Policies. **Module 4: Independent India** Policies towards Forestry – Forest Policy Resolutions and Acts (1952, 1980 and 1988) – Policies towards Environment - Role of NGOs – Environmental Movements**:** Chipko Movement - Appiko Movement – Scientific Conservation of Environment – Environmental Ethics - Major International Environmental Conventions and Protocols.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Lectures/tutorials/assignments/self-study/seminars/field work based write up.	
References/Readings:	1. Allchin B. and Allchin F.R. 1968. The Birth of Indian Civilisation. Harmondsworth, Penguin. 2. Alvares C. (Ed.) 2002. Fish Curry and Rice, A sourcebook on Goa, its ecology and life-style, Goa, The Goa Foundation, Revised 4th Edition. 3. Arnold D. and Guha R. (Eds.) 1996. Nature, Culture, Imperialism, Essays on the Environmental History of South Asia, Delhi, OUP.	

4. Bellamy P. 2007. Dictionary of Environment, New Delhi, Academic (India) Publishers. 3rd Edition.
5. Chakrabarti R. (Ed.) 2007. Situating Environmental History, New Delhi, Manohar.
6. Dasgupta P. 1982. The Control of Resources, Delhi, OUP.
7. Desai A.R. (Ed.) 1979. Agrarian Struggles in India, Delhi, OUP.
8. Dhavalika, M.K. 1988. The First Farmers of the Deccan, Pune, Deccan College.
9. Fernandes W. and Menon G. 1987. Tribal Women and Forest Economy: Deforestation, Exploitation and Status Change, New Delhi, Indian Social Institute.
10. Gadgil M. and Guha R. 2008. The Use and Abuse of Nature (incorporating This Fissured Land An Ecological History of India and Ecology and Equity), (Omnibus edition), New Delhi, OUP, Fifth Impression.
11. Gill, Singh M., and Kewlani J. (Eds.) 2009. Environmental Conscience Socio- *Legal and Judicial Paradigm*, New Delhi, Concept Publishing Co.
12. Guha R. (Ed.) 1982. *Subaltern Studies*, Vol. I, Delhi, OUP.
13. Guha R. 1983. Forestry in British and Post-British India: A Historical Analysis. Economic and Political Weekly. Vol.18, No.44, pp.1882-1896.
14. Guha R. 1983. Forestry in British and Post-British India: A Historical Analysis. Economic and Political Weekly. Vol.18, No.45/46, pp.1940-1947.
15. Guha R. and Gadgil M. 1989. State Forestry and Social Conflict in British India. Past and Present, No.123, PP.141-177.
16. Guha R. 1989. The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya, Delhi, OUP, Berkeley: University of California Press.
17. Guha R. 1999. Sumit, Environment & Ethnicity in India 1200-1991, Cambridge, CUP.
18. Joseph B. 2009. Environmental Studies, New Delhi, Tata McGraw-Hill Pubg. Co. 2nd Edition.
19. Krishna, Murali K.V.S.G., and Venkata Rao M.V. 1998. Our Environment, Kakinada, Environmental Protection Society. 1st Edition.
20. Murthy, Linga and others, (Eds.). 2008. Environmental Concerns of Economic Development, New Delhi, Serials Publications.
21. Raju A.J. and Solomon. 2007. A Textbook of Ecotourism Ecorestoration and Sustainable Development, Kolkata, New Central Book Agency.
22. Singh K.S. (Ed.). 1983. Tribal Movements in India, Vo. II, New Delhi, Manohar.

Learning Outcomes	1. Understand the environmental history of India through the ages from the ancient to the modern. 2. Appreciate Cultural Ecology and its significance. 3. Comprehend Environmental Ethics. 4. Understand sustainable development, rational use of natural resources, renewable sources of energy, and methods of controlling pollution.	

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Title of the Course: Women and Environment

Course Code: ESO-354 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Under graduate degree in any subject.	
Objective:	1. This course will provide students with an understanding of the relationship between women and environment. 2. Students will be introduced to basic concepts and terms to enable the understanding of the gendered impact of environmental concerns, human-made and natural disasters, women's agency, knowledge of traditional healing systems and women's role as farmers. 3. Environmental movements and conservation both past and present particularly women's role in them will also be discussed. 4. Through this course students will get an insight into initiatives and commitments on women and the environment. 5. The course will highlight the inter-connectedness of ecosystems, environment, society and gender which are important for sustainable development.	
Content:	**Module 1: Understanding Concepts 1** a) Gender Equality and Equity b) Gendered impacts of day to day environmental concerns, human-made and natural disasters due to patriarchy, stereotypes and socially constructed division of labour. **Module 2: Understanding Concepts 2** a) Eco-feminism b) Feminist Political Ecology c) Feminist Environmentalism d) Gender Mainstreaming and Auditing	06 hours 10 hours

	Module 3: Women's involvement in environmental movements and conservation: past and present a) Movements (e.g. Chipko, Silent Valley, Green Belt, Narmada Bachao Andolan, Navdanya and contemporary movements) b) Conservation: Seed cooperatives and traditional knowledge systems, community forestry. **Module 4: Initiatives and instruments for gender and environment** a) UN Environment Programme (Gender) – Gender and Water Alliance (GWA), - Global Gender and Climate Alliance (GGCA), - Women's Earth and Climate Action Network, International (WECAN) b) Greenpeace c) 350.org d) Pani Panchayat e) Paani Foundation	10 hours 10 hours
Pedagogy:	Lectures/assignments/workshops/ brain storming sessions/outreach programmes/campus walks/documentaries and discussion/ presentations	
References/Readings	1. Buckingham S. 2020. Gender and Environment. London: Routledge. 2nd Edition. 2. Jiggins J. 1994. Changing the Boundaries Women-Centered Perspectives on Population and Environment. Washington D.C.: Island Press. 3. Krishna S. 2003. Livelihood and Gender: Equity in Community Resource Management. New Delhi: Sage Publications. 4. Martínez-Alier, J. 2002. The environmentalism of the poor: a study of ecological conflicts and valuation. Cheltenham: Edward Elgar Publishing Ltd. 5. McCully P. 1996. Silenced Rivers: The Ecology and Politics of Large Dams. ZED books. 6. Mies, Maria, and Shiva V. 2014. Ecofeminism. New York: Zed books. 7. Rocheleau D., Thomas-Slayter B., and Esther W. 1996. "Gender and Environment A Feminist Political Ecology Perspective." In Feminist Political Ecology Global Issues and Local Experience, 1–22. London: Routledge. 1st Edition. 8. Shiva V. 2005. Globalization's New Wars: Seed, Water and Life forms, New Delhi: Women Unlimited.	

	9. Shiva V. 1998. Staying Alive: Women, Ecology and Survival in India. New Delhi: Kali for Women. 10. Wangari M. 2004. The Green Belt Movement: Sharing the Approach and the Experience. New York: Lantern Books. 11. Agarwal B. 1992. "The Gender and Environment Debate: Lessons from India." Feminist Studies, Inc. 18 (1): 119–58. 12. Agarwal B. 2000. "Conceptualizing Environmental Collective Action: Why Gender Matters." Cambridge Journal of Economics 24 (3):283–310. 13. Gupte M. 2004. "Participation in a Gendered Environment: The Case of Community Forestry in India." Human Ecology 32 (3): 365–82. 14. Gupte M. 2008. "Gender, Feminist Consciousness, and the Environment". Women & Politics 24 (1): 47–62. 15. Shobhita J. 1984. "Women and People's Ecological Movement A Case Study of Women's Role in the Chipko Movement in Uttar Pradesh." Economic & Political Weekly XIX (41): 1788–94. 16. https://panipanchayat.org/ 17. https://www.paanifoundation.in/ 18. https://350.org/ 19. OSAGI Gender Mainstreaming - Concepts and definitions (un.org) 20. https://www.unep.org/explore-topics/gender/about-gender 21. Guide on Gender Mainstreaming Environmental Management Projects.2015. United Nations Industrial Development Organization, Vienna 22. https://www.unido.org/sites/default/files/2015-02/Gender_Environmental_Management_Projects_0.pdf	
Learning Outcomes	1. Students will understand the relationship between gender and the environment. 2. Students will acquire knowledge about global and local initiatives on gender and environment. 3. Students will understand the vital role that women play in conservation of nature, sustainable use of natural resource, mitigating environmental conflicts and addressing environmental issues through activism.	

Title of the Course: Environmental Security: Dimensions and Perspectives

Course Code: ESO-355 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the Course:	Open to all PG enrolled students on GU Campus

Objective:	The course beholds the following objectives: 1. Aims to disseminate rudimentary knowledge in the realm of environmental security, aligned with concurrent analytical comprehension of the natural and human induced environmental mutations, plausibly impacting human security and well-being. 2. Disseminating knowledge and information coalesced around conflicts impelled by environmental resources-scarcity and instituted peace-building processes. 3. Endeavouring to emphasise on typologies and taxonomies of environmental stresses, such as demographics and migration, the dialectic choices between conventional and renewable energy sources, and socio-economic underpinnings of poverty-led insecurity, contextualised to national, region and global environs.	
Content:	**Module 1: Introduction** Conceptual-Construct and Topical Phenomenon – Definitions, Narratives in Discourse, Schools of Thought.	06 hours
	Module 2: 'Environmental Security' qua 'Conventional' and 'Non-Conventional' Security Typologies of Armed Conflicts &Analysis; Inter-State Conflicts in the Global South (Case Studies from Africa, West Asia, South Asia); Population Pressures and Migration Patterns in Conflict; Role of Non-State Actors; Socio-Economic Issues (Poverty, Occupation and Livelihoods, Infectious Diseases, Industrialisation and Urbanisation Trends)	10 hours
	Module 3: Environmental Security and Sustainability Imperatives for Ecological Harmony and Development: Food Security; Water Scarcity; Energy Security and Independence; Coastal, Marine, and Blue Economy Resources; Climate Change; Natural Resources Administration; Disaster Management; Land and Forests Vulnerability.	10 hours
	Module 4: Environmental Security as Global Commons and Global Good Perspective on Challenges; Template for Cooperation; Environmental Peace-building Movements, Environmental	10 hours

	Justice.	
Pedagogy:	Classroom lectures, written and oral assignments, audio-visual presentations	
References/ Readings	1. Das O. 2013. Environmental protection, Security and Armed Conflict: a sustainable development perspective, Edward Elgar Publishing Ltd. 2. Hough P. 2021. Environmental security: an introduction, Routledge (2nd Ed.). 3. Lanicci J. et. al. 2020. Environmental security – concepts, challenges and case studies, AMS. 4. Lee J. 2019. Environmental conflict and cooperation: premise, purpose, persuasion and promise, Routledge (1st Ed.). 5. Pirages D. et al. 2011. Ecological and non-traditional security challenges in South Asia, NBR Special Report. 6. Richard M. 2010. Global environmental change and human security, London: MIT Press. 7. Scheffran J. et al. 2012. Climate change, human security and violent conflict: challenges for societal stability, Springer.	
Learning Outcomes	Upon completion of instruction and pedagogy, the course will render students, the following takeaways: 1. Acquaint and introduce them, to the latest thought-process discourse, in terms of theory and praxis, on environmental security and peace-building, in a manner that helps internalise the conceptual phenomenon, as cross-cutting generations, policy-axes, and vectors of human endeavour. 2. Glean as to how environmental harness and the excesses of it materially impinge, on the natural security calculus of individual nation-states, inducing the imperative for responsible and sustainable recourses, by sovereign and institutional actors, alike. 3. Internalise how environmental preservation and protection remains pivotal, to beneficently shaping critical sustainable development concerns, of water, food and energy security, that intimately segue with existential aspects of upholding livelihoods and fostering societal-uplift, vide ecological sentience. 4. Students can emerge as stakeholder-contributors to wide-ranging policy analysis in environmental security and peace, through requisite appraisal and appreciation of policy formulations and interventions, beyond their chosen domain of scientific core competence.	

Title of the Course: Global Environmental Governance

Course Code: ESO-356 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022-23

Prerequisites for the course:	Open to all opting for MA/MSc in Environmental Science	
Objective:	1. To provide interdisciplinary knowledge and competences that assist in dealing with environmental governance in an international context. 2. This inter-disciplinary course provides in-depth insights to the actors, processes and problems of global environmental politics and aims to summarise debates about 'global' environmental problem. 3. It will also aim to understand the various international organisations and their role in global governance. 4. The main focus of the course is on understanding the evolution of environmental policy regimes at multiple scales and with multiple actors.	
Content:	**Module 1. Introduction** Globalization of Environmental Threats and Impact on Security, Trade, Health and Development.	06 hours
	Module 2. Core Dimensions and Key Actors of Global Environmental Governance Actors, Institutions—International Organizations—the UN System; Sustainable Development Goals (SDGs); Environment Summits—From Stockholm to Rio to Johannesburg; India's Environmental Diplomacy.	10 hours
	Module 3. Environmental Accords and Governance History of Environment's Lawmaking and Institution Building Processes—1987 Brundtland Commission Report, International Environmental Agencies including UNEP, Commission on Sustainable Development, Select Multilateral Environmental Agreements-Agreements on Climate Change, Antarctica Treaty, Polar Regions and the Amazonia.	10 hours
	Module 4. The Indigenous and Environmental Governance in Comparative Perspective: Case Studies from the High North (Polar Region) and the Amazonia Evolving Indigenous Governance in the Arctic; Rights of Minorities and Indigenous Peoples in the Arctic Region; Indigenous People and the Amazonia—Issues, Challenges and	10 hours

	Governance of the Region; Role of Groups and Questions of Land and Water Rights in the High North and the Amazonia.	
Pedagogy:	Lecture classes, interactions, assignments, presentations	
References/Readings	1. Chasek P. S., Downie D. L., and Brown J. W. 2017. Global environmental politics: dilemmas in world politics, New York: Routledge. 2. Dauvergne P. 2005. Handbook of global environmental politics. Cheltenham: Edward Elgar. 3. Elliot J. A. 2010. An introduction to sustainable development. New York: Routledge. 4. Jakobson L. and N. Melvin. 2016. The new Arctic governance. Oxford: Oxford University Press. 5. Lalfagianni A., Fuchs D., and Hayden A.. Eds. 2020. Routledge handbook of global sustainability governance. London: Routledge. 6. Nicholson S. and Wapner P. 2014. Global environmental politics: from person to planet. London: Routledge. 7. Speth J. G. and Haas P. M. Eds. 2006. Global environment governance. London: Oisland Press. 8. Delmas M. A. and Young O. R. Eds. 2009. Governance for the environment. Cambridge: Cambridge University Press. 9. Andonova L. B., and Hoffmann M. J. 2012. From Rio to Rio and beyond: innovation in global environmental governance. The Journal of Environment & Development. 21(1): 57-61. 10. Andonova L. B., Betsill M. and H. Bulkeley. 2009. Transnational climate governance. Global Environmental Politics. 9(2): 52–73. 11. Chase, V. M. 2019. The changing face of environmental governance in the Brazilian Amazon: indigenous and traditional peoples promoting norm diffusion. Revista Brasiliera de Politica Internacional. 62 12. Dubash N. K. 2012. Toward enabling and inclusive global environmental governance. The Journal of Environment & Development. 21(1): 48-51. 13. Esty D. C. 2009. Revitalizing global environmental governance for climate change. Global Governance. 15(4): 427-434. 14. Hey E. 2006. International institutions and global environmental governance. Proceedings of the Annual Meeting. 100 (29 March - 1 April): 310-312.	

	15. Johnson S. 2021. Indigeneity, environment, and governance in the Amazon: the impact of indigenous movements on environmental conservation policy in nation-states of the Amazon rainforest. https://academiccommons.columbia.edu/doi/10.7916/d8-9vvv-rk15/ 16. Rechkemmer A. 2003. Rio and the origins of global environmental governance. Security and Peace. 21(3/4): 173-178. 17. Toohey D. E. 2012. Indigenous peoples, environmental groups, networks and the political economy of rainforest destruction in Brazil. International Journal of Peace Studies. 17(1): 73-97. 18. Global environmental governance: a reform agenda. 2006. Winnipeg: International Institute for Sustainable Development (IISD).	
Learning Outcomes	At the end of the course, the students can retrieve, recognize, and recall knowledge acquired from the course (including lectures, readings, and assignments) on: 1. Global environmental problems and issues. 2. Concepts and theories. 3. International organizations and regimes. 4. Different types of actors and the roles they play in global environmental governance.	

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Title of the Course: Global Environmental History

Course Code: ESO-357 **Number of Credits:** 03

Total Contact Hours: 36 **Effective from AY:** 2022–23

Prerequisites for the course:	There is no prerequisite for this course apart from the programme requirements.
Objectives:	Global Environmental History focusses on the interactions that humans have with nature. Natural world comes in many forms, scales, and styles—forests, rivers, mountains and climate, which makes it a remarkable tool for understanding science, society and nation. This course examines natural world as active, rather than passive; how nature influences humans, how humans intervene in nature and how is nature shaped by human action.

Content:	**Module 1: Ecology as destiny?** Humans and nature in a time-dimension: Ibn Khaldun; Montesquieu; George Perkins Marsh; Fernand Braudel. **Module 2: Early Human Condition: Ecological process** Historicizing climate; Early humans; Early Agriculture; the Metal Ages. **Module 3: Commodity Frontiers and Natural Assets** Columbian exchange; Industrial world; Fossil fuels; Environmental Relationships. **Module 4: Nations and nature** Environment and empire—Imperialism and environmental change; Significance of *Silent Spring*; science and the discourse of ecological crisis; the ideology of scientific conservation, the environmental debate, green capitalists, environmental justice.	06 hours 10 hours 10 hours 10 hours
Pedagogy:	Lectures (traditional, problem-based, discussion-based); tutorials; assignment-based; seminars; cooperative learning and self-study.	
References/Readings	1. Anker P. 2002. Imperial Ecology. Cambridge, MA. 2. Arnold D. and R. Guha 1995. Nature, culture, and imperialism: essays on the environmental history of south Asia, Delhi. 3. Beinart W and Hughes L. 2009. Environment and empire. Oxford. 4. Crosby A. 1972. The Columbian exchange: biological and cultural consequences of 1492, Westport. 5. ————————. 1986. Ecological imperialism: the biological expansion of Europe, 900–1900. New York. 6. Diamond J. 1997. Guns, germs, and steel: the fates of human societies, New York. 7. ————————————. 2005. Collpase: how societies choose to fail or succeed, New York. 8. Grove R. 1995. Green imperialism. New York. 9. Guha R. 2000. Environmentalism: a global history. New York. 10. Hornborg A., McNeill J. R. and Martínez–Alier J. 2007. Rethinking nvironmental history. New York. 11. Hughes J. D. 2001. An environmental history of the world.	

	London. 12. Khaldun I. 1967. The muqaddimah: an introduction to history. Princeton. 13. Marks R. 2002. The origins of the modern world. Lanham. 14. Marsh G. P. 1864. Man and nature. Cambridge. 15. McNeill J. R. 2003. Observations on the nature and culture of environmental history, History and Theory, Vol. 42 (4), pp. 5–43. 16. McNeill J. R and Engelke P. 2015. An environmental history of the anthropocene since 1945. London. 17. McNeill W. H. 1980. The human condition: an ecological and historical view. Princeton. 18. Ponting C. 1991. A green history of the world. London. 19. Radkau J. 2008. Nature and power: a global history of the environment. Cambridge, UK. 20. Richards J. F. 2014. The world hunt: an environmental history of the commodification of animals. Berkeley. 21. Simmons I. G. 2008. Global Environmental History 10,000 BC to AD 2000. 22. Tucker R and Russell E. 2004. Natural enemy, eatural ally. Corvallis.	
Learning Outcomes	1. Understand the historical relationship between humans and the environment. 2. Recognise the ways in which humans modified and adapted nature. 3. Analyse the nature of environmental change that world has gone through historically and how they have impacted nations and different segments of society. 4. An ethic which applies to the whole of nature, including humans.	

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