Post Graduate Programme in Environmental Sciences

Courses of study, Schemes of Examinations & Syllabi
(Choice Based Credit System)

SYLLABUS 2023
Onwards

DEPARTMENT OF ENVIRONMENTAL SCIENCES

BISHOP HEBER COLLEGE

(AUTONOMOUS)

Affiliated to Bharathidasan University
Nationally reaccredited with 'A' Grade by NAAC
Recognized by UGC as "**College of Excellence**"
"Star College" Status Awarded by the DBT
DST-FIST Sponsored College
Tiruchirappalli – 620 017
Tamil Nadu, India

TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	**M.Sc. ENVIRONMENTAL SCIENCE**
Programme Code	
Duration	**2 years for PG**
Programme Outcomes (Pos)	**PO1: Problem Solving Skill** Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context. **PO2: Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making. **PO3: Ethical Value** Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities. **PO4: Communication Skill** Ability to develop communication, managerial and interpersonal skills. **PO5: Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals. **PO6: Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment. **PO7: Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur. **PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society. **PO 9 Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and a global perspective. **PO 10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one's life.
Programme Specific Outcomes (PSOs)	**PSO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions. **PSO 2 - Entrepreneur** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations. **PSO3 – Research and Development** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO 5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

M.Sc., ENVIRONMENTAL SCIENCE - PROGRAMME STRUCTURE

S.No	Course Code	Courses	Title of the Paper	T/P	Credits	Hour/ Week	Marks		
I-Semester							**I**	**E**	**Total**
1	P23ES101	Core 1	Principles of Ecology	T	5	7	25	75	100
2	P23ES102	Core 2	Environmental Pollution	T	5	7	25	75	100
3	P23ES1P1	Core Practical 1	Lab-I: Ecological Methods, Environmental Pollution and Environmental Chemistry	P	4	6	40	60	100
4	P23ES1:A	Elective 1	Environmental Chemistry	T	3	5	25	75	100
5	P23ES1:B P23ES1:C	Elective 2	**Environmental Laws and Policies /** Disaster Management	T	3	5	25	75	100
					20	**30**			
II-Semester									
6	P23ES203	Core 3	Environmental Microbiology	T	5	6	25	75	100
7	P23ES204	Core 4	Environmental Biotechnology	T	5	6	25	75	100
8	P23ES2P2	Core Practical 2	Lab-II: Environmental Microbiology, Biotechnology and Toxicology	P	4	6	40	60	100
9	P23ES2:A	Elective 3	Environmental Toxicology	T	3	4	25	75	100
10	P23ES2:B P23ES2:C	Elective 4	**Biodiversity and Conservation /** Bioremediation	T	3	4	25	75	100
11	P23ES2E1	NMEC I	Env. Management	T	2	4	25	75	100
					22	**30**			
III-Semester									
12	P23ES305	Core 5	Biostatistics & Research Methodology	T	5	6	25	75	100
13	P23ES306	Core 6	Remote Sensing & GIS	T	5	6	25	75	100
14	P23ES307	Core 7	Environmental Impact Assessment	T	5	6	25	75	100
15	P23ES3P3	Core Practical 3	Lab-III: Biostatistics, Remote sensing and GIS and EIA	P	4	6	40	60	100
16	P23ES3:A P23ES3:B	Elective 5	**Instrumentation & Analytical Techniques** / Environmental Education	T	3	3	25	75	100
17	P23ES3E1	NMEC II	Ecotourism	T	2	3	25	75	100
	P23ES3I1	Internship	Industry Exposure & Internship	P	2	-	100	-	100
					26	**30**			
IV-Semester									
18	P23ES408	Core 8	Occupational Health Hazards& Industrial Safety	T	5	6	25	75	100
19	P23ES409	Core 9	Climate Change	T	5	6	25	75	100
20	P23ES4PJ	Project	Core Project work with Viva Voce		7	8	40	60	100
21	P23ES4:A	Elective 6	Natural Resource Management	T	3	4	25	75	100
	P23ES4S1	SEC	Ecosystem visit and Environmental Audit	P	2	4	100	-	100
	P23ETA41	Extension Activity	Environmental Awareness, PRA, PBR and Green Initiatives	P	1	-	-	-	100
	P23VLO41 P23VLO42	VLO	The Big Picture Flying High		2	2	100	-	100
					25	**30**			
			TOTAL		**93**				

Semester-I				
Course code: P23ES101	**Core Course-I**	**T/P**	**C**	**H/W**
	Principles of Ecology	**T**	**5**	**7**
Objectives	This course is to make the students to understand the basic information about the earth And environment. They will also learn about the interactions between the components of our environment, ecology and also about environmental issues and its sustainability.			
Unit-I	**Introduction to Ecology** Definition, principles and scope of ecology, human ecology and human settlements, Evolution, origin of life and speciation, Ecosystem stability-cyber natics and ecosystem regulation, Concept of Ecosphere and Biosphere, evolution of biosphere.			
Unit-II	**Biomes and Habitat** Classification of biomes–Tundra, Taiga, Grassland, Desert, Evergreen and deciduous forests, Tropical rain forests and their characteristics, flora and fauna; Classification of Aquatic Habitats –Fresh water pond, Wetlands, Beels, Rivers– their characteristics, flora and fauna; Marine Habitats–Pelagic, Benthic, Inter-tidal Estuarine; Mangroves–their characteristics, flora and fauna.			
Unit- III	**Ecosystem structure and functions** Abiotic and biotic component, Energy flow, food chain,foodweb,EcologicalPyramids-types,biogeochemicalcycles,CommunityEcology**:**Definitionandconceptofcommunity,community diversity,structure,dominance,stratificationandperiodicity.Ecadsandecotypes,Edgeeffect and EcologicalNiche,ecologicalsuccession characteristics, types of succession, concept of climax, significance of succession.			
Unit-IV	**Population ecology** Attributes of population - density, natality, mortality, survivorship curves, age distribution, growth curves and models, r & k selection; Population interactions - Types: inter-specific and intra-specific; positive and negative interactions; Mutualism – concept and types, Commensalism – Types – Phoresy, Inquilinism, Metabiosis Competition – Types, Concepts - evolutionary strategies, competition exclusion principle, character displacement, Predation – prey predator concept; predator adaptations; antipredator adaptations; co-evolution of prey- predator interactions – Red Queen hypothesis; role in ecosystems; Lotka-Volterra equations for prey predator relationship; Competition-predation trade-off, Parasitism - Host-parasite interactions; Parasites and parasitoids, disease, Herbivory - Plant-herbivore interactions; Herbivory and plant defenses.			
Unit-V	**Ecological Tools** Fundamental concepts of sampling methods in ecology - Sampling vegetation, sampling phytoplankton, sampling periphyton, sampling insects, sampling reptiles, sampling birds, survey of mammals - Direct method, Indirect count, Analysis of data; Quantitative assessment of diversity - Species area curve, species abundance distribution, Girth class distribution, Estimation of Density, Frequency, Relative Frequency, Richness, Abundance, Evenness, IVI Diversity scales - Alpha, Beta and Gamma Diversity. Diversity indices - Simpson Index, Shannon Wiener Index, Jaccard's Similarity Index			

ReferenceandTextbooks:

- Eugene P.Odum (2017).*Ecology*. Oxford and IBH Publishing Co.Pvt.Ltd.
- Manuel Molles (2015).*Ecology:ConceptsandApplications*.7th Edition.McGraw-HillEducation.
- Pratibha Singh, Anoop Singh & Piyush Malaviya (2009)Text Book of Environment & Ecology– Excel Publishers.
- RanaS.V.S.(2009)*EssentialsofEcologyandEnvironmentalScience*.PrenticeHallPublishersLtd.
- SharmaP.D.(2012).*Ecology and Environment*. Rastogi Publications

Outcomes	Upon successful completion of the course, the student an ➢ Understand the principles, scope and components of the earth and environment ➢ Know the basic concepts of ecology and ecosystems, factors and its interaction along with its succession processes. ➢ Learns about various environmental issues and environmental sustainability. ➢ Apply the knowledge of basic ecology in field studies.

	Apply the tools of ecology in the field.

Semester-I				
Coursecode P23ES102	**CoreCourse-II**	**T/P**	**C**	**H/W**
	EnvironmentalPollution	**T**	**5**	**7**
Objectives	➢ To get deeper in sights in to fundamentals of water, air and soil pollution, monitoring and analysis of environmental pollution ➢ To realize, monitor and analyses the impacts of pollution, environmental problems and its control measures.			
Unit-I	Concepts of atmosphere and Air Pollutants (Sources and classifications- indoor, vehicular, industrial and other sources). Meterological aspects of Plume and stack dispersion, Chemical reactions of air pollution (Formation of fog and smog, acid rain).Ozone depletion–Montreal protocol; Global warming –Kyoto protocol. Air quality standards, Monitoring of air pollution (Ambient air quality monitoring, Stack monitoring; PM 10 and PM 2.5)– Cleaner technologies (Settling chamber, Cyclones, Fabric filter, Electrostatic precipitator, Wetscrubber, Control of gaseous pollutants absorption, adsorption and combustion Recovery system)–online monitoring of pollution.			
Unit-II	Properties of water; physiochemical and bacteriological properties of water, drinking water quality standards; Water pollution- Classification (ground water, river, Marine) ources and sinks, Eutrophication. Control measures of water pollution (adsorption, flocculation, ion exchange and reverse osmosis). Preventive measures in industries to avoid water pollutions(Endofpipetreatmentsanditsalternatives,onlinemonitoringandtreatmentofindustrial effluents).			
Unit- III	Soil pollution; Definition; broad classification, Sources and broad classification of pollution (*e.g.*urban areas, industrial areas, agriculture and livestock, landfills, sewage sludge, municipal solid waste dumps and hazardous waste),Soil quality and their impactsonphysio-chemicalandbiologicalpropertiesofsoilandplants,SedimentPollution–Black carbon – Soil pollution control measures – On site (in situ) chemical, physical, soilvapourextraction,soilwashingsolidification/stabilization,electro-kinetic remediation thermical and biological methods. Off site (ex-situ, on-site and off-site): chemical methods, Physicalsolidification/ stabilization/ immobilization, thermal, and biological (bioremediation and phytoremediation), Biostimulation, Bioaugmentation, Isolation Containment of the affected area.			
Unit -IV	Concepts and types of municipal and Hazardous Solid Wastes (Hospital Wastes, Radioactive Wastes, industrial), Transport and waste minimization techniques (Disposal, leachate and landfill gas management Nuclear reactor safety). Legislation on management and handling of municipal solid wastes and hazardous wastes Light pollution and control measures; and Thermal pollution and control measures. Noise pollution–Sensing, Measurement, Abatement measures.			
Unit-V	Evaluation of Industrial Disasters and Pollution – Case studies – Chemical Industries–Pesticide Industries, Bhopal Disaster, Chernobyl accident, Love canal Disaster, Oil Disasters–Exxon, British Petroleum-Gulf of Mexico; e-wastes, Impact and Remedial Measures.			

Reference and Textbooks:

- AhluwaliaV.K (2014).*EnvironmentalPollutionandHealth*.TheEnergyandResourcesInstitute,TERI
- AvinashChauhan(2020)*EnvironmentalPollutionandManagement*.IKInternationalPublishersLtd
- GuptaO.P(2019).*ElementsofEnvironmentalPollutionControl*.KhannaPublication.
- MarkBrusseau,IanPepper,CharlesGerba(2019)*EnvironmentalandPollutionScience*,3rdEdition,AcademicPress
- Rao.C.S.(2018).*Environ mentalPollutionControlEngineering*.3rdEdition.NewAgeInternationalPublication.
- Shafi,S.M(2005)EnvironmentalPollution.AtlanticPublishersandDistributors.

Outcomes	Onsuccessfulcompletionofthecourse, ➢ The students will be able to understand the basic principles and fundamentals ofAir/Soil/Waterpollutantsandtheirimpactonenvironment. ➢ Studentswillbeabletogaindetailedknowledgeonlocalandglobalenvironmentalissues andanalyzechemicalprocessesinvolvedindifferentenvironmentalproblems

Semester-I				
Coursecode P23ES1P1	**Core Practical I**	**T/P**	**C**	**H/W**
	Lab-I: Ecological Methods, Environmental Pollution and Environmental Chemistry	**P**	**4**	**6**

Objectives The course demonstrates concepts in modern ecology, methods to analyze pollution and environmental applications.

I. Ecological Methods

Field Survey and Sampling Methods
Inventory of floral and faunal biodiversity of campus
List and selective description of flora and fauna

Primary productivity of an aquatic ecosystem – Estimation of GP P and NPP
Carbon sequestration potential of selected trees

Ecological Data Collection, Interpretation and Presentation

Quantitative assessment of herbal plants - Estimation of density, frequency, frequency class, abundance, relative abundance and species richness, Importance Value Index; Biotic index – Shannon Weiner Index;

II. Water Quality Analysis

Selection of sampling sites and collection of methods of samples

Water Quality Parameters

pH, electrical conductivity, turbidity, total dissolved solids, ammonia (as total ammonia–N), Calcium, Chloride, Fluoride, Iron, Iron, magnesium, nitrate, sulphate, total alkalinity, total hardness, sodium, potassium, Sodium Absorption ratio, MPN

Demand Parameters

Dissolved Oxygen, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) (one sample from clear water source and another sample from a polluted water preferably sewage or industrial effluent)

III. Soil Quality Analysis

pH, Electrical Conductivity, Alkalinity, Total Organic Matter, Total Phosphorous, Total Nitrogen, Sodium, Potassium, Ca, Mg, C:N ratio. Soil texture- sand, silt, clay.

ReferenceandTextbooks:

- Barani TharanBalamurali S (2016). *Environmental Engineering Laboratory Manual*: CreatespaceIndependentPublishingPlatform.
- KhopkarS.M.*Environmental Pollution Analysis*. NewAgeInternational(P)Ltd.,Publication.

DarrellS.Vodopich(2009).*Ecology Lab Manual*. McGraw Hill.

- GopalanR (2020).*ALaboratoryManualforEnvironmentalChemistry*.DreamtechPress.

Outcomes On the successful completion of the course, students will be able to

- Students gain ability to setup basic and advanced ecological sampling techniques in different ecosystems.

Semester-I				
Course code P23ES1:A	**Elective I**	**T/P**	**C**	**H/W**
	Environmental Chemistry	**T**	**3**	**5**

Objectives	➢ The course introduces the concept and scope of environmental chemistry including soil chemistry, chemical composition of air and water treatment technologies. ➢ The course also develop an understanding of basics of chemistry in relevance to environment and such as, solutions preparation, chemical reactions and their effects on the environment, to provide students with an understanding of the fundamental Chemical processes occurred on environment.
Unit-I	Concept and scope of Environmental Chemistry; acid base reactions, Stoichiometry, Gibb's energy, Chemical potential, Chemical equilibrium, acid-base, reactions. Solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated Hydro carbons, Radio nuclides.
Unit-II	Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermo chemical and photo chemical reactions in the atmosphere.
Unit- III	First law of thermodynamics, enthalphy, adiabatictrans formations, second law of the rmodynamics, Carnot's cycle, entropy, Gibb's free energy, chemical potential, phase equilibria, Gibb's Donnan equilibrium, third law of thermodynamics, enzymes catalysis, Michaelis/Menten equation.
Unit -IV	Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical Smog Chemistry ofwater, concept of D.O., B.O.D., and C.O.D, water treatment: Sedimentation, Coagulation, Filtration, tertiary and advanced treatment, redox potential.
Unit-V	Soil Chemistry-Chemical and miner biological composition of soil, Physical properties of soil – texture, bulk density, permeability; Chemical properties – cation exchange capacity, pH, macro and micro nutrients. Chemical compounds - detergents and bleaching agents, Hydrocarbons, PAH, PCBs, chlorofluorocarbons, pesticides.

Reference and Textbooks:

- BalramPani, (2007) *Text Book of Environmental Chemistry*, I.K.International Publishing House PVT.Ltd.
- DaraS, Mishra D.D(2006).*ATextbookofEnvironmentalChemistryandPollutionControl*.S.ChandPublication.
- Gary W.Van Loon, Stephen J.Duffy (2017).*Environmental Chemistry: A global perspective*.
  - 4th Edition.OUPOxford.
- GirardJ.E.(2015)*PrinciplesofEnvironmentalChemistry*.
- JulianE.Andrews,Peter Brimblecombe, Tim D.Jickells, Peter S.Liss, BrianReid (2013). *An Introduction to Environmental Chemistry*. Wiley-Blackwell Publication.
- Rao,C.S.(2018)*Environmental Pollution Control Engineering*, 3rdEdition, NewAgeInternational (P)LtdPublishers.

Outcomes	On successful completion of the course, the students ➢ Have knowledge of basic theories and problems of Environmental chemistry ➢ Describe important chemical reactions and cyclic processes of chemical species in the atmosphere, hydrosphere and in lithosphere ➢ Demonstrate knowledge of chemical principles of various fundamental environmental phenomena ➢ Apply basic chemical concepts in understanding the behavior of pollutants ➢ Analyze chemical processes involved in air, water and soil environmental problems ➢ Knowthedifferenttypesoftoxicandhazardoussubstancesandanalyzetheir Toxicological information

Semester-I				
Coursecode	**Elective II**	**T/P**	**C**	**H/W**
P23ES1:B	**ENVIRONMENTAL LAWS AND POLICIES**	**T**	**3**	**5**
Objectives	➢ To impart knowledge about environment allaws, regulations and policies of India and international environmental laws.			
Unit-I	International environmental policy – environmental problems and their impact on international system, the instruments of international environmental policy-Transnational environmental policies–the Indus river basin, the Ganga–Brahmaputra River basin system			
Unit-II	Environmental planning – concepts and approaches and strategic of environmental planning and management. International Environmental laws. Necessity for International Environmental Court. United Nations Environment Programme [UNEP] role on international environment laws. Case studies for International environmental disputes.			
Unit- III	Constitutional and legislative provisions : constitutional provisions and the environment, environmental protection and fundamental rights, judicial remedies and procedures, Tort law, public nuisance, the writ jurisdiction, statutory remedies, public in terestlitigation, class action, freedom of information and the right to know. Environmental policy in India – National Environmental Policy 2006. National Forest Policy 1988, National Water Policy 2002.			
Unit -IV	Indian legislation to protect the environment: The Water (Prevention and Control of Pollution) Cess Act, 1977, The Air (Prevention and Control of Pollution) Act, 1981, – The Environmental (Protection) Act, 1986 - Noise pollution control rules 2000, Waste management rules – Solid waste, Hazardous waste, Bio-medical waste, E-waste. and judicial responses on these legislations. All with Latest amendments (till 2022).			
Unit-V	The Indian forest act of 1927, The wildlife protection act 1972; The forest conservation act 1980; National Green Tribunal Act, 2010 – All with Latest amendments (till 2022); The factories act of 1948. theminesandmineralsactof1957. The atomic energy act of 1962, ThepublicLiabilityinsuranceactof1991, thenationalenvironmentappellateauthorityactof1997.			

Reference and Textbooks:

- Gurudeep Singh (2005) *Environmental law in India*–McMillan, New Delhi.
- Shyam Diwan and Armin Rosencrany, 2001, *Environmental law and policy in India*, Oxford University Press, New Delhi.
- *Pollution Control Legislations*, Vol.I and II, 1999, Tamilnadu Pollution Control Board, Chennai.
- NathB., Hens, L., Compton, P and D.Devuyst(1998), *Environmental Managementin Practice*, VolI, Routledge, London and NewYork.
- The ISO14000 Handbook: Joseph Cascio. ISO14004–*Environmental management systems*: *General guidelines on principles*, systems and supporting techniques (ISO14004:1996(E).ISO14001:*Environmental management systems*: Specific at ion with guidance for use (ISO 14001:1996b (E)).(Internationalorganizationforstandardization–Switzerland).

Outcomes	On the successful completion of the course, students will be able to ➢ Understand environmental legislation and policies of national and international regime. ➢ Have an insight in to major acts and rules applicable for pollution control and natural resource conservation. ➢ Develop the skills needed for interpreting laws, policies and judicial decisions about the environment. ➢ Know regulations applicable to industries and other organizations with significant environmental aspects. ➢ Apply the legislation concepts for solving the local environmental problems. ➢ Get knowledge of the legal system operating in India. ➢ Be in apposition to prepare compliance reports for getting environmental clearance Prepare the environmental management system for an organization

Semester-I				
Coursecode: P23ES1:C	**Elective** II	**T/P**	**C**	**H/W**
	DISASTER MANAGEMENT	**T**	**3**	**5**
Objectives	➢ To Understand basic concepts in Disaster Management & mitigation, Definitions and Terminologies used in Disaster Management, understand various types of Disasters and to understand Impacts of Disasters and Risk Management.			
Unit-I	Definition–Hazards as natural process-Benefits and importance of disasters Nature disaster-creeping disaster- creeping disaster- Death and Damage – Evaluating hazards –Human response to hazards .Changes in Coastal zone, coastal erosion, beach protection. Coastal erosion due to natural and manmade structures.			
Unit-II	Major threats to coastal ecosystem –Habitat loss – Landslides – Sea level change, Degradation of water quality, Fisheries resource depletion, Earthquakes, Tsunami, Volcanic activity, Coastal flooding, Cyclones, Erosion,. Sea water intrusion, Cause and preventive measures. Impact on Environment Forecasting and Warning System – Disaster Profile of India.			
Unit- III	Disaster Management. Pre disaster Planning - Toning of Disaster – prone areas – prioritization – regulations – protection measures during disaster and Post disaster. Relief Camp Organization – Survey and Assessment. Disaster Management Cycle –Vulnerability Analysis – Disaster Training –Legal Aspects –case studies for disasters and management. Technology for Disaster Management –Role of Information and communication technology, GPS, Remote sensing and Geo graphic Information system in Disaster Management.			
Unit -IV	Disaster Preparedness and Training. Community Preparedness in Natural Disasters-Role of information, education, communication and training -Roles and responsibilities of different national and international agencies and government -NGO, Armed forces, Paramilitary forces, Community based organizations (CBO) – Army Training for Disaster Reduction–Role of team and co-ordination-Training needs.			
Unit-V	Mitigation Strategies: Disaster Mitigation–emerging trends in disaster management-UN draft resolution on Strengthening of Coordination of Humanitarian Emergency Assistance, International Decade for Natural Disaster Reduction (IDNDR), Policy for disaster reduction, problems of financing and insurance. Training for emergency. Regulation/guidelines for disaster tolerance building structures.			

Reference and Textbooks:

- DavidR. God schalk, *Natural Hazard Mitigation: Recasting Disaster Policy and Planning* (Editor), Timothy Beatley, Phillip Berke, DavidJ. Bowe, EdwardJ. Kaiser Charles C.Bohl, R.Matthew Goebel, Isl and press:(January1999), ISBN1559636025
- Natural Disaster Management, Tudor Rose, 6 Friar Lane Leicester LE15RA United kingdom. Jeff Groman (2002) The Atlas of Natural Disasters by (Author) Publisher: Friedman/ Fairfa Publishing; (March 2002).
- Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
- Sharma,R.K.&Sharma,G.(2005) (ed) Natural Disaster, APH Publishing Corporation, New Delhi
- Carter, NW. *Disaster Management*: Adisaster Manager's Handbook, Asian Development Bank, Manila. (1992).
- Gautam Ashutosh1994.*Earthquake: A Natural Disaster*. Ashok Publishing House. New Delhi.SinghR.B.2006*Natural Hazards and Disaster Management*; Vulnerability and Mitigation.
- Rawat Publications. JochenZschau,AndreasN.Kuppers(2003). *Early warning Systems for Natural Disaster Reduction.* Springer-Verlag, Berlin Heidelberg.

Outcomes	Onthesuccessfulcompletionofthecourse,studentswillbeableto ➢ UnderstandtheEmergency/DisasterManagementCycle. ➢ DevelopabasicunderstandingofPrevention,Mitigation,Preparedness,Responseand Recovery

Semester-II				
Course code: P23ES203	**Core Course- 4**	**T/P**	**C**	**H/W**
	Environmental Microbiology	**T**	**5**	**6**
Objectives	This course is designed to provide a basic understanding on microbiology and in-depth knowledge of role of beneficial and pathogenic microorganism in environment.			
Unit-I	Introductory microbiology; Microbiology - organisms in nature & their importance: Classification of microorganisms, Criteria for classification; nutritional types, Scope of Environmental Microbiology; microbial growth and metabolism Microbial metabolism energy production, utilization of energy & Biosynthesis. Role of microbes in human life and environment.			
Unit-II	Diversity of environmental microbes – Distribution– microbiology of aquaticenvironment (fresh, marine and other aquatic environment), microbiology of terrestrial environment. Aeromicrobiology – outdoor and Indoor, aerosols, Adaptation of microorganisms to the air environment; extremophiles (archae bacteria, acidophilic, alkalophilic, thermophilic, barophilic and osmophilic and radiodurant microbes).			
Unit III	Role of microorganisms in natural system and artificial system; Influence of Microbes onthe Earth's Environment and Inhabitants; interspecies microbial interactions, Ecological impacts of microbes, Symbiosis (Nitrogen fixation and ruminant symbiosis); microbial interactions in a biofilm, Plant – Microbe interaction (Beneficial and pathogenic), animal –microbe interactions (Beneficial and pathogenic) Role of Microorganism in Nutrient cycles.			
Unit IV	Bio indicator organisms in Environment- air water and soil (Bacteria, algae, bacteriophages and other organisms). Standard criteria of indication, Bio-indication of water quality (surface and ground water) – Coli forms - total coli forms, E-coli, Streptococcus, Clostridium, Concentration and detection of virus. Microbial pathogensis (Human, Animal and Plant health), Transmission of pathogens to higher organisms –Bacterial, Viral, Protozoan, and Helminths, Control of microorganisms.			
UnitV	Microbial Diversity & Systematics Molecular biology methods - Microbial ecology (Metagenomics); Functional and genetic diversity of microbial communities (DNA heterogeneity by reannealing denatured environmental DNA, ARDRA, measuring metabolic capabilities using BIOLOG, microtitre plates, using DNA probes and PCR primers, in situ hybridization of intact cells).			

Reference and Textbooks:

- Bertrand,J- C., Caumette, P.andLebaron, P. (2015), *Environmental Microbiology: Fundamentals and Applications: Microbial Ecology*, Springer.
- Jjemba, P. K.(2004), *Environmental Microbiology: Principles and Applications*, SciencePublishers Inc., Enfield.
- Maier, R., Pepper, I. and Gerba, C. (2008), *Environmental Microbiology*, Academic Press.Mitchel, R.(2009),*Environmental Microbiology*, 2nd edition, Wiley-Blackwell.
- Mohapatra, P. K. (2008), *Textbook of Environmental Microbiology*, I.K. International (P)Ltd.
- Pepper, I. L., Gerba, C. P. and Gentry, T. J. (2015), *Environmental Microbiology*, 3rdedition, Academia Press, Elsevier.
- Schmidt, T. M. and Schaechter, M. (2012), *Topics in Ecological and EnvironmentalMicrobiology*, 3rdedition, Academia Press,Elsevier.
- Uhrig, B.(2017), *Environmental Microbiology*, Lulu.com Publisher.

Outcomes	On successful completion of the course, the students ➢ understand basic of microbiology and recent developments in environmentalmicrobiology.

Semester-II				
Course code: P23ES204	**Core Course- 4**	**T/P**	**C**	**H/W**
	Environmental Biotechnology	**T**	**5**	**6**
Objectives	➢ The course introduces knowledge of biotechnological approaches and techniques for Environmental management and remediation of various environmental pollutants. ➢ impart knowledge of biotechnological approaches and techniques for Environmental management and remediation of various environmental pollutants.			
Unit-I	**Emerging technology for bioremediation**- Restriction endonucleases Recombinant DNA Technology, techniques of restriction mapping-vectors-plasmid PBR 322 and Lamda phage, cosmid construction of chimeric DNA, Genomic and cDNA libraries - Polymerase Chain Reaction (PCR) and development of gene probes for environmental remediation.			
Unit-II	**Microbial biodegradation-** Xenobiotic compounds: Aliphatic, Aromatics, Polyaromatic Hydrocarbons, Polycyclic aromatic compounds, Pesticides, detergents, Surfactants and microbial treatment of oil pollution. Microbial Systems for Heavy Metal Accumulation, Biosorption& detoxification mechanisms, oil spills, plastic degradation by microbes. phytoremidiation.			
Unit- III	**Biotechnology for Resource Management-** New Bioremediation Technologies to Remove Heavy Metals and Radionuclides; Oil field microbiology; Improved oil recovery; Role of environmental biotechnology in resource management – Bioremediation – energy production - mineral and energy recovery, Biosensor Technology for monitoring pollutants - Planning and management of bioremediation and Environmental biotechnology processes.			
Unit -IV	**Industrial Biotechnology**- Fermentation Technology-Design of Immobilized Enzyme Reactors – Packed – bed, Fluidized- bed and Membrane reactors-Application and advantages. **Agricultural biotechnology-** Evolution in Agriculture-Biotechnology and Sustainable Production. (biofertilizers –Rhizobium, Azolla; Biopesticides-Bt insecticide.) Advantages and applications of biofertilizers, biopesticides **Forestry and Biotechnology-** micro-propagation; Somaclonal variations; Induction of genetic variability and heriditability; Conservation of endangered species; Biotechnology in preservation of bio-diversity; In situ and ex situ conservation through gene banks.			
Unit-V	**Bioethics, Biosafety and IPR-** Bioethics– ethical concerns of biotechnology research and innovation of Genetically modified plants, animals and microbes, genetically modified food, Potential effect on Environment and Human health by transgenic plants-Human genome project - ICMR Ethical Guidelines for Biomedical Research on Human Subjects. Objectives and salient features of Biosaftey guidelines and regulations - Rights Intellectual property rights-TRIP- GATT - Plant variety protection.			

Reference and Text books:

- Chatterji A.K (2011). *Introduction to Environmental Biotechnology*. Prentice Hall India Learning Private Limited.
- Evano, G. H. and Furlong, J. C.(2004),*Environmental Biotechnology* – Theory and Application,John Wiley and Sons, USA.
- Gareth M. Evans, Judith C. Furlong (2012). *Environmental Biotechnology – Theory andApplication*. 2nd Edition. Wiley India Pvt Ltd.
- Jjemba, P. K. (2004), *Environmental Microbiology* – Theory and Application, Science Pub. Inc., USA.
- Olguin, C. J., Sanchez, G., Hernandez. E. (2000), *Environmental Biotechnology and CleanerBioprocesses*, Taylor & Francis.
- Pepper, I.L. and Gerba, C. P. (2005), *Environmental Microbiology* - Laboratory Manual, Elsevier, USA.
- Ratledge, C. and Kristiansen, B. (2003), *Basic Biotechnology*, 2nd edition, Cambridge University Press.
- Viswanath Buddolla (2017). E*nvironmental Biotechnology: Basic Concepts and Applications*. AlphaScience International Ltd

Outcomes	On successful completion of the course, the students ➢ Will obtain the knowledge of Existing and emerging biotechnological approaches in remediation of pollution and environmental management. ➢ Implement various practical approaches to address environmental issues relevant to environmental biotechnology.

Semester-II				
Course code: P23ES2P2	**Core Practical II**	**T/P**	**C**	**H/W**
	Lab-II: Environmental Microbiology, Biotechnology and Toxicology	**P**	**4**	**6**

Objectives

- The course provides practical guidelines on conducting experiments across the entire spectrum of environmental toxicology, biotechnology and microbiology.

1. Good Microbiology laboratory practices: Laboratory safety (Dos and Don'ts),
2. To prepare basic liquid (Nutrient broth) and basic solid media (Nutrient Agar and Potato Dextrose Agar) for cultivation of bacteria and fungi.
3. To learn pure culture techniques used for isolation and purification of microorganisms a. Pour plate method b. Spread plate method c. Streak plate method
4. To perform different staining methods to study morphological and structural characteristics of bacteria and fungi a. Simple staining b. Gram Staining c. Fungal staining (Lacto-phenol cotton blue)
5. Enumeration of microbes from soil and air
6. Examination of Mycorrhizae – VAM
7. Isolation of genomic DNA from bacteria
8. Isolation of genomic DNA from plant
9. Isolation of genomic DNA from animal tissue
10. Estimation of reducing sugars in toxic waste.
11. Estimation of protein from toxic waste.
12. Case studies on environmental effects of pesticides.

Reference and Textbooks:

- Alexander N. Glazer Hiroshi Nikaido (1995) *Microbial Biotechnology*, WH Freeman andCompany, NY, USA.
- Bernaral R. Glick and Jack J. Pastemak (1994) *Molecular Biotechnology: Principles andApplications of Recombinant DNA*, ASM Press. Washington, DC USA.
- Brown, T.A. (1995) Gene cloning - *A introduction* - Chapman & Hall, London.
- David Woolley, Adam Woolley (2013). *A Guide to Practical Toxicology: Evaluation,Prediction, and Risk*. 2nd Edition. Taylor and Francis Publication.
- Dr. Ratna Trivedi (2016). *Practical Manual of Environmental, Microbiology and Biotechnology*. Academic press.
- Glazer and Nikaido (1995) Microbial Biotechnology. WH Freeman & Co., New York.
- Jayanta Kumar Patra, Gitishree Das, Swagat Kumar Das, HrudayanathThatoi (2020). A *Practical Guideto Environmental Biotechnology (Learning Materials in Biosciences)*. Springer publication.

Outcomes

On the successful completion of the course, students will be able to

- Explain the role of microbes in degradation of environmental pollutants
- Acquire skills in manipulating the microbes for biodegradation of pollutants.
- Develop processes for waste bioconversion to value-added products.
- Become an entrepreneur/researcher in the areas of environmental biotechnology.

Semester-II				
Course code: P23ES2:A	**Elective III**	**T/P**	**C**	**H/W**
	Environmental Toxicology	**T**	**3**	**4**
Objectives	This course is designed to offer an outline on toxicology, including an introduction of the major groups of pollutants, their fate in the environment, their disposition in organisms and their mechanisms of toxicity. The toxicity assessment of pollutants in biological and Environmental systems is also included.			
Unit-I	**Introduction to Toxicology and Toxicants:** Definition of Toxicology, Toxicity and Toxicants. Classification of toxic agents – natural toxins (Animal, Plant and microbial toxins) and Anthropogenic toxicants (Chemical toxins). Classes of environmental toxicants; Inorganic ions (Metals-Hg, Anions-NO_3), Organic contaminants (Hydrocarbons and PCBs) – Organo chlorine insecticides (DDT and Aldrin), Organo phosphorus insecticides (Parathion, Carbomates and Pyrethroids). Detergents, Pharmaceuticals and Personal Care Products.			
Unit-II	**Entry, Distribution and Mode of Action:** Routes of Entry – Inhalation, Absorption, Ingestion, Injection. Bio-distribution, Bio-magnification and Biotransformation. Types of Toxicity – Acute, Sub-acute and Chronic. Effects of Toxicants- Short Term and Long term. Dose Response Relationship- LC_{50}, LD_{50}, EC_{50}. OSHA Permissible Exposure Limits (PELS). Mode of Action - Reactions of Toxicants with Target Molecules			
Unit III	**Systemic Toxicology I:** Dermal Toxicants and Effects (Primary Irritation, Sensitization, Photoallergy and Phototoxicity, Cutaneous Cancer). Respiratory Toxicants and Effects - Pulmonary (Irritation, Cellular Damage, Oedema and Lung Cancer). Hepatotoxicants and Effects – Fatty Liver (Steatosis), Liver Necrosis, Cirrhosis, Cholestasis, Viral like Hepatitis. Nephrotoxicants and their Effects.			
Unit IV	**Systemic Toxicology II:** Neurotoxicants and Effects (Neuronopathy, Axonopathy). Effect of Toxicants on Reproductive and Cardiovascular System. Endocrine Disrupting Chemicals and their Toxicity. Immuno toxicants – Mechanisms of Immuno-toxicity, Immuno - suppression, Direct and indirect Effects of Toxicants, Immune Mediated Diseases, (Hypersensitivity and Allergy)			
UnitV	**Ecotoxico genomics, Toxicity Testing and Risk Assessment of Toxicants:** Introductionto Toxico genomics, Toxico proteomics and Metabolonomics. Definition of Risk Assessment, Elements of Risk Assessment -Categories of Risk Assessment – Retroactive and Predictive, Risk Assessor, Risk Manager, Hazard Index, NAS Paradigm and its Components**.**			

Reference and Textbooks:

- Bertrand,J.C, Caumette, P.andLebaron, P (2015). *Environmental Microbiology:Fundamentalsand Applications: Microbial Ecology*. Springer publications.
- C. H. Walker, S.P. Hopkin, R. M. Sibly and D.B. Peakall, (2006), *Priciples of Ecotoxicology*,Third Edition, CRC Press (Taylor & Francis Group).
- Daniel A. Vallero, (2005), *Environmental Contaminants-Assessment and Control*, AcademicPress.
- David J. Hojjman, Barnett A. Rattner, G. Allen Burton, Jr., and John Cairns, Jr.,(2000),
    - *Handbook of Ecotoxicology*, CRC Press (Taylor & Francis Group).
- Environmental Toxicants-Human Exposure and Their Health Effects, Morton Lippmann,(2000), John Wiley and Sons Publication.
- Katalin Gruiz, Tams Meggyes and Eva Fenyvesi,(2014),*Environmental Toxicology*- Engineering Tools for Environmental Risk Management, CRC Press (Taylor & FrancisGroup).
    - LU's Basic Toxicology (Fundamentals, Target Organs and Risk Assessment), Sixth Edition, Samkacew and Byung-Mu Lee,(2013), CRC Press (Taylor & Francis Group).
- Michael C. Newman, (2001), *Fundamentals of Ecotoxicology*, Lewis Publishers.
- Ming-Ho Yu, (2004), *Environmental Toxicology* – Biological and Health Effects of Pollutants, Second Edition, CRC Press (Taylor & Francis Group).
- Pepper I. L, Gerba C. P and Gentry T. J. (2015). *Environmental Microbiology*. 3rd Edition, Academia Press.
- Robert Burke, (2000), *Hazardous Materials Chemistry for Emergency Responders*, LewisPublishers.
- Schmidt, T. M. and Schaechter, M (2012). *Topics in Ecological and EnvironmentalMicrobiology*. 3rd Edition, Academia Press.
- Wayne .G. Landis, Ming Ho Yu, 3rd Ed. (2002) *Introduction to Environmental Toxicology*,Lewis Publishers, CRC press , NY.

Outcomes	On successful completion of the course, the students will ➢ Get an outline on toxicology, including an introduction of the major classes of pollutants, their fate in the environment, their disposition in organisms and their mechanisms of toxicity. ➢ Know the basis of toxicology and an overview about natural and anthropogenic toxicants ➢ comprehend the entry, distribution and mode of action of the toxicants in the environment ➢ Explain the effects of toxicants in various systems like respiratory, excretory, reproductive and cardiovascular. ➢ Be trained in the field of toxicity testing methods and assessments of risks caused by toxicants.

Semester-II				
Coursecode: P23ES2:B	**Elective 4**	**T/P**	**C**	**H/W**
	BIODIVERSITYANDCONSERVATION	**T**	**3**	**4**
Objectives	Biodiversity describes the organisms in the natural environment, which provide the ecosystem services that form our natural capital: fresh water, clean air, soil fertility and biological pest control. Biodiversity is fundamental to the future sustainability of the world's natural resources. Conservation of biodiversity, one conomic grounds alone, needs to become core business in the management of our natural resources.			
Unit-I	**Scope and Constraints of Biodiversity Science :**Biological Diversity: Species –Origin of new species, Description of new species, Community and ecosystem diversity, Genetic diversity-Systematics in Diversity –Environment and Genetic Variations –Biological Classification – Phylogenetic Relationship – Ecological Biodiversity –Species Concept –Biological and Phylogenic Concepts; Species Inventory – Biodiversity hot spots. IUCN conservation categories– Red data book.			
Unit-II	**Species Diversity:** Global Distribution of Species- Tropical species diversity –Diversity in terrestrial, marine and freshwater –Micro-organisms-lower and higher plants–lower and higher invertebrates and vertebrates; Species extinction and Endangered species; Monitoring indicator species and habitats; Threats to biodiversity: Extinction –Past rate of Extinction–Human Caused Extinctions–Endemic species-Extinction rates-Man and animal conflicts.			
Unit-III	**Habitats and Ecosystem:** History of ecosystem ecology, Human induced Ecosystem change, Urban Ecosystem Classification Ecosystem mapping, tropical forests, grasslands, wetlands, coral reefs, mangroves; Habitat lass: Habitat destruction –Fragmentation and degradation – desertification –Habitat restoration; Invasive Species: their introduction pathways, biological impacts of invasive species on terrestrial and aquatic systems; Impacts of Exploitation on Target and Non-target Terrestrial and Aquatic species and Ecosystems.			
Unit -IV	**Values of Biodiversity** Instrumental/ Utilitarian value and their categories, Direct use value; Indirect/ Non consumptive use value, Introduction to Ecological Economics; Monetizing the value of Biodiversity; Intrinsic Value; Ethical and aesthetic values, Anthropocentrism, Biocentrism, Ecocentrism and Religions; Intellectual Value; Economics of Ecosystem, Green Revolution, Food Plants, medicinal and ornamental plants, animal uses–livestock and fisheries.			
Unit-V	**Conservation and Management** National Legislation– Biological diversity Act, 2002 - ForestconservationAct1980; National Biodiversity Act and National Biodiversity Authority. Current Practices in Conservation- in*situ* Conservation – Protection of Natural Habitats- National and International Protected Areas; *exsitu* Conservation - Conservation of plants and animals – Concept of Community conserved Areas (CCAs)-Ranges and significance of CCAs- sacred groves and traditional knowledge; Environmental ethics; Biodiversity- Socio–Political Perspective – special conservation projects - project tiger, project elephant. International approaches to conservation and sustainable development- Multilateral Treaties–Biodiversity Conventions – Protection of Wild flora and Fauna – Ongoing problems – possible responses- role of conservation biologists.			

Reference and Textbooks:

- Chaudhuri,A.B.andD.D.Sarkar(2003),*Megadiversity Conservation, flora, Fauna and Medicinal Plants of India's hotspots*, Daya Publishing House, Delhi.
- Singh,M.P.,B.S.SinghandSomaS.Dey(2004),*Conservation of Biodiversity and Natural Resources*. Daya Publishing House, Delhi.
- DadhichL.K.andA.P.Sharma(2002),*Biodiversity Strategies for Conservation*, APH Publishing Corporation, New Delhi.
- Khan,T.IandDhariNAlAjmi(1999),*Global Biodiversity* Conservation Measure, Pointer Publishers, Jaipur.
- Krishnamurthy,K.V(2003),*An Advanced Textbook on Biodiversity*– Principles and Practice, Oxford and IBH Publishing, NewDelhi.
- T.B.1:Krishnamurthy,KV.,2003,*Anadvanced Textbook on biodiversity*, Oxford and IBH Book. Co., New Delhi.
- T.B.2:Hall, BK.andHallgrimsson,B.,2014.*Evolution*,5thEdition,JohnesandBartlettIndiaPvt.Ltd.New Delhi.
- Ridley,M.,,2004,*Evolution*,3rd Edition, Black well Science Ltd a Black well Publishing company, USA.

Outcomes	Protected and restored marine and estuarine ecosystems. Controlled invasive species, Mitigated dry land alinity, Promoted ecologically sustainable grazing, Minimized impacts of climate change on biodiversity, Maintained and record indigenous peoples' Ethno biological knowledge, Improved scientific knowledge and access to information.

Semester-II				
Coursecode: P23ES2:C	**Elective IV**	**T/P**	**C**	**H/W**
	BIOREMEDIATION	**T**	**3**	**4**

Objectives	As an introduction course, it includes an overview of the bioremediation process; describe the typical bioremediation strategies for contaminated environment; explore the applications of bioremediation technologies; discuss the factors that influence the bioremediation rates; and introduce success cases in the application of bioremediation Technology to contaminated sites.
Unit-I	Bioremediation - factors affecting bioremediation, types. Organic pollutants - aerobic and an aerobic degradation of organic pollutants-degradation of aliphatic, aromatic, poly aromatic and chlorinated compounds, bio techniques for air pollution abatement and odour control – bio scrubbers, bio beds, bio trickling filters, bio deterioration.
Unit-II	Bioremediation of inorganic pollutants –Heavy metals and radionuclides-microbial interaction with metallic elements - molecular mechanism of metal resistance, biosorption and biotransformation of metals and radionuclides, bio mining, Nitrate-Nitrification and denitrification -Phosphate-Biological Phosphate removal, Phytoremediation.
Unit III	Waste utilization and management, Bioplastics, Biosensor technology, Biofuels, Vermitechnology, SCP, Biofertilizer.
UnitIV	Molecular techniques in bioremediation – pathway construction Biochemical background, Operonde regulation, Vectors, Hybrid pathways and enzymes, Non catabolic genes for catabolic pathway construction, Rational enzyme redesign.
UnitV	GEM–degradative plasmids, promoting GEM survival–implications for bioremediation, preventing GEM survival – suicide contaminant systems – GMOs in foodproduction–transgeniccrops–Biosafety–Bioethics–Patents–Patentlawsand regulation.

ReferenceandTextbooks:

- Ronaldl. Crawford and Don.l. Crawford, 1996, *Bioremediation*–Principles and Applications, Cambridge University Press.
- NuzhatAhmed,FouadM.QureshiandObaidY.Khan,2006*Industrial and Environmental Biotechnology*–Horizon Press
- Paul.A.Rochelle, 2001 *Environmental Molecular Biology*, Horizon Press.

Outcomes	On successful completion of the course, Students will ➢ Understand the nature and importance of bioremediation; ➢ Know the influence of site characteristics to bioremediation rates; ➢ Have knowledge of the impacts of contaminant characteristics to bioremediation process Understand the use of bioremediation in real world applications

Semester-II				
Coursecode P23ES2E1	**NMEC I**	**T/P**	**C**	**H/W**
	ENVIRONMENTAL MANAGEMENT	**T**	**2**	**4**
Objectives	➢ To impart the knowledge on global and local environmental issues ➢ To introduce the concepts of manage the natural resources ➢ To explore the management techniques of water, land and forest resources			
Unit-I	Global Environmental issues – Natural resource depletion, global warming, Ozone Depletion, climate change; Causes – Habitat destruction, Urbanization, industrialization, over exploitation, population explosion, lack of awareness. Regional environmental issues. Environmental Management Strategy - Prevention – Enforcement – Monitoring – Education & Partnership			
Unit-II	Sustainable Water management (SWM): Water resources; Methods of water management Conservation including rain water harvest and watershed management), Allocation, retrofit program and Behavioral practices			
Unit-III	Sustainable Land Management (SLM): Land use pattern; Land degradation – types, causes impacts and control measures; Sustainable agriculture: Impacts of unsustainable agriculture, Sustainable agricultural practices - Water efficient agriculture, soil and nutrient amendments, integrated pests and weed management, crop rotation, poly culture / inter cropping, organic agriculture, alternative agriculture – urban agriculture, regenerative agriculture, integrated farming.			
Unit -IV	Sustainable Forest Management (SFM): principles and techniques of SFM - Policy and Legislation, planning, harvesting, protection, legal arrangements and monitoring and research Forest management in India – Social forestry schemes, Joint Forest Management			
Unit-V	Disaster management: Types of disaster – natural, manmade, complex emergencies, environmental disaster and pandemic emergencies. Disaster management strategy: prevention, preparedness, response and recovery Management – flood, earth quakes, cyclone;			
Outcomes	➢ Understand the causes of environmental issues ➢ Apply the knowledge to manage the water, land and forest resources ➢ Respond effectively to disaster episodes.			

Reference and Textbooks:

- Kothari, C.R (1996), *Quantitative Techniques*, Vikas Publishing Housing Pvt Ltd, Hyderabad.
- Kothari,C.R., (1989), *Research Methodology – Methods and Techniques*. Wiley Eastern, NewDelhi.
- Miller,J., (1989), *Statistics for Advanced Level*, Cambridge University Press. Rastogi V.B (2009). *Fundamentals of Statistics*. ANE Books.
- Snedcor, G.W. and Cochran, .G.(1982), *Statistical Methods*, Academic Press. Vittal,R.R.(1986) *Business Mathematics and Statistics*, Murgham Publications.
- Wardlaw,A.C.(1985),*PracticalStatisticsforExperimentalBiologists.*WileyChichester.
- Sharma,B.A.V., RavindraPrasad,D. and Satyanarayana,P (1989)*Research Methods in SocialSciences*.SterlingPublishersPvt.Ltd.
- WayneW.Daniel,ChadL.Cross(2014).*Biostatistics: Basic Concepts and Methodology for the Health Sciences*.10thEdition.WileyPublication.

Outcomes	On successful completion of the course, the students ➢ Know the types of research and scientific data bases, report writing and plagiarism. ➢ Chose the research that they want to carry out. ➢ Identify and design their research problems. ➢ Understand the principles of research methods and instruments required for their research experiments. ➢ Apply their knowledge on instrumentation for environmental analysis, and field Works and data collection.

Semester-III				
Course code: P23ES305	**Core Course - V**	**T/P**	**C**	**H/W**
	Biostatistics and research methodology	**T**	**4**	**4**

Objectives	To impart understanding on the concepts of biostatistics and to improve the Computing knowledge of the statistical methods related to environment.
Unit-I	**Basic statistics:**Schemes for Classification-Tabulation and representation of data–science population numerical data in science-Sampling theory–Measures of central tendency and dispersion–Correlation and regression-Analysis-Probability –Theoretical distribution-Analysis of one way variance-Methods of analysing oceanographic data and filtering of scientific data.
Unit-II	Sampling Methods: Probability sampling, random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgement sampling, quota sampling.
Unit-III	Tests of Significance– Mass and alternative hypothesis– error level of significance–Equal and Unequal Sampling - t, z, x2 test, Analysis of variance – One way ANOVA–Two way ANOVA – Regression and correlation - simple and multiple. Introduction to environmental system analysis, Approaches to development of models, models of Population growth and interaction-various models.
Unit-IV	Applications of Computer in Environmental Science and Management –Data Analysis using packages (SPSS): Editing, Data Tabulation, Descriptive statistics, Multivariate Analysis – Correlation – Regression –Cluster analysis – Factor Analysis -PCA, Graph Plotting, Computational databases and environmental management.
• **Unit -V**	Scientific documentation: Methods of literature collection, design, planning and execution of investigation, Preparation of scientific documents, general articles, research papers, review articles, editing of research papers, methods of citation, collection of literatures, including web based methods, bibliography and thesis writing. Presentation techniques, effective communication skill.

Reference and Textbooks:

- Arvind Shende and Vijay Upagade (2010).*Research Methodology*. S.Chand Publications.
- Bliss, G.I.(1970), *Statistics in Biology*. McGraw Hill Book Company, Vol. I and II. New Delhi.
- Byron S Gottfried (1996), *Programming with C*, Hill Publishing Co, New Delhi. Gupta S.P. (2014).*Statistical Methods*. Sultan Chand & Sons Publications.
- Gupta,S.P.(1996)*Statistical Methods*, Sultan Chand & Sons Publications, New Delhi. Haynes, R (1982) *Environmental Science Methods*, Chapman & Hall, London.
- Khan, I. A and Kanum,A.,(1994)*Fundamentals of Bio-Statistics*, Ukaaz Publication, Hyderabad.
- Kothari,C.R (1996), *Quantitative Techniques*, Vikas Publishing Housing Pvt Ltd, Hyderabad.
- Kothari,C.R.,(1989),*Research Methodology Methods and Techniques*. Wiley Eastern, New Delhi.
- Miller,J., (1989), *Statistics for Advanced Level*, Cambridge University Press.
- Rastogi V.B(2009). *Fundamentals of Statistics*. ANE Books.
- Snedcor,G.W. and Cochran, W.G.(1982), *Statistical Methods*, Academic Press. Vittal, R.R.(1986) *Business Mathematics and Statistics*, Murgham Publications.
- Wardlaw,A.C.(1985),*Practical Statistics for Experimental Biologists*. Wiley Chichester.

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- Sharma,B.A.V., RavindraPrasad,D. and Satyanarayana,P (1989) *Research Methods in Social Sciences*. Sterling Publishers Pvt. Ltd.
- Wayne W. Daniel, Chad L. Cross(2014). *Biostatistics: Basic Concepts and Methodology for the Health Sciences*. 10th Edition.Wiley Publication.

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<tr><td>Outcomes</td><td>On successful completion of the course, the students
➢ Know the types of research and scientific databases, report writing and plagiarism.
➢ Chose the research that they want to carryout.
➢ Identify and design their research problems.
➢ Understand the principles of research methods and instruments required for their research experiments.
➢ Apply their knowledge on instrumentation for environmental analysis and fieldworks and data collection.</td></tr>
</table>

Semester-III				
Course code: P23ES306	**Core Course - VI**	**T/P**	**C**	**H/W**
	Remote Sensing & GIS	**T**	**5**	**6**

Objectives	To teach the principles and applications of spatial information technologies viz RS, GPS and GIS about the distribution of resources. To give hands-on training on the uses of GIS Software in environmental studies.
Unit-I	Elements of photographic systems and computer applications. Land stat. IRS and other satellite systems- satellite data. Principles involved in thermal IR image and microwave image interpretation. Applications of different types of images in earth Sciences, Environmental Sciences, Archeology, Marine studies, Forestry, Soils, Hazard management, etc.
Unit-II	Concepts and foundations of remote sensing – History of remote sensing-Electro-magnetic energy–Properties and interaction with the earth. Atmospheric windows. Black, white and grey bodies, sources of EMR. Image interpretations. Aerial photo – classification based on attitude of camera lens, distortions caused due to flight irregularities, overlaps, scale, relief displacement and its effects. Photo recognition elements. Different types of photographs
Unit-III	Introduction to Geographical Information Systems and GIS software, Fundamentals of GIS: Layers and features, Raster/Vector-Georeferencing and projection, Spatial data and GIS basics; Data attributes and spatial topology, Projection/ Image registration, Digitization and data attributes -map data representation, GPS.
Unit-IV	GIS Applications: Resources mapping, Inventory and monitoring natural resources, Landcover mapping, Wetland mapping – Applications to Agriculture -Water Management, Specific Applications-Infrastructure–Ground Water. GPS applications– Principles of Accuracy–Data base Creation–Networking of Data.
Unit-V	Remote sensing applications–Impact Assessment–Pollution Monitoring–Water–Air – Ocean Pollution – Land Degradation – Desertification – Industry – Mining –Ground Water Modeling– Damage Assessment–Coastal and Marine applications–Future Sensors–Satellite System– ENVISAT–Megha Tropiques–TRMM–EOS Missions–Integral Earth Observation Studies– Global Change- Case studies.

Reference and Textbooks:

- Barrett,E.C and Curtis,L.F (1982). Introduction to Environmental Remote Sensing, Basudeb Bhatta (2008). *Remote Sensing and GIS*. OUP India.
- Danson,F.M and Plummer,S.E (1995), Advances in Environmental Remote Sensing, Space Remote Sensing Systems–An Introduction, Chen, H.S (1985).
- Fischer, M.M and Nijkamp,P (1993). Geographic Information Systems, Spatial Modeling and Policy Evaluation, Springer–Verlag.
- Jensen(2013). *Remote Sensing of the Environment: An Earth Resource Perspective*. Pearson Education India.
- KramerJ.Herbert(2002), Observation of Earth and its Environment–Survey of Missions and Sensors Springer Verlag.
- Fundamentals of Remote Sensing, George Joseph (2003), Universities Press (India)Ltd., Hyderguda, Hyderabad
- MartinWegmann, Benjamin Leutner and Stefan Dech (2016). *Remote Sensing and GIS for Ecologists: Using Open Source Software (DataintheWild).* Pelagic Publication.
- Muralikrishna,I.V(1995).Remote Sensing and GIS for Environmental Planning, Tata-McGraw Hill.
- Roody,G.MandCurran,P.J.(1994).Environmental Remote Sensing from Regional and Global Scales,

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- Singh,R.B (1992), Environmental Monitoring: Applications of Remote Sensing and GIS, Geo cartho International Centre, HonkHong.William KPratt (2001),
- Digital Image Processing, John Wiley & Sons.

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<tr><td>Outcomes</td><td>On successful completion of the course, students can
➢ Recognize that Remote Sensing and Geographic Information System (RS-GIS) can be a powerful tool for geospatial analysis.
➢ Acquaint adequate knowledge on principles and basic concepts of environmental geoinformatics
➢ Understand the basic concepts of GIS and its mechanisms
➢ Know the various types of GPS systems
➢ Learns to interpret satellite images
➢ Able to apply the tools of remote sensing and GIS for environmental disaster management and conservation
➢ Understand Image Classification Techniques, Image enhancement and interpretation methods
➢ Use GPS for various environmental applications.</td></tr>
</table>

Semester-III				
Course code: P23ES307	**Core Course-VII**	**T/P**	**C**	**H/W**
	ENVIRONMENTALIMPACTASSESSMENT	**T**	**5**	**6**

Objectives	This course tells about the need of industry and society to predict and include environmental concerns and risks while developing projects. The course also describes the modern tools and techniques to evaluate the environmental impacts and outlines Various management options needed to mitigate these risks.
Unit-I	**Fundamentals of EIA:** Definition and Evaluation of EIA in India – Types of Impact-Characteristics - Steps of EIA- Framework for EIA, Screening, Scoping and Baseline Studies, Significance and Importance of Impacts, Impact Prediction-Mitigation Aspects-Assessment of Alternatives, Public Hearing, Decision Making-Techniques for Assessment of Impacts on Physical Resources, Ecological Resources, Human use Values and Quality of Life Values. EIA guidelines, Govt. of India EIA Notifications 1994. 2006 and amendments up to 2020. NABET criteria for EIA consultants NRBT criteria for EIA consultants, NABL.
Unit-II	**EIA Methodologies:** ADHOC, Overlays, Matrix, Checklist and Network approach. Battle Columbus Technique and modeling. EIA Process, EIS and EMP. Public Consultation, list of industries attracting EIA, Environmental Clearance. Composition of expert committee, Terms of Reference, EIA Report Preparation.
Unit III	**Environmental Impact Analysis and Assessment:** Air, Noise, Water, Land, flora and fauna, Socio – economic and biotic environment. Environmental setting, Identification, evaluation, and prediction of environmental impacts. **Risk Assessment:** Human Health Risk Assessment, Ecological Risk Assessment, Probabilistic Risk Assessment. The role of Risk assessment in Environmental Management decision. Evaluation of human health risks associated with airborne exposures. Risk management and risk communication. Life Cycle Assessment and Cost Benefit Analysis.
UnitIV	**Environmental Audit:** Guidelines, planning for Environmental Audit. Life cycle analysis, Cost Benefit Analysis. Industrial safety and OHSA systems and ISO 27001. 45001 & OHSAS 18001, Environmental Management Systems. Cleaner production technologies, Eco-mark, and Eco labelling schemes.
UnitV	**Case Studies:** Land Clearing Projects-Dam Sites-EIA for Aquaculture, Steel, Mines, Hydro Thermal, Nuclear, Oil and Gas based Power Plants- Highway Projects-Industrial Projects. Damage to Coral Reefs in Oceans.

Reference and Textbooks:

- Bregmam J.I(1999),Environmental Impact Statements, Lewis Publishers, London.
- Charles H. Eccleston(2011).*Environmental Impact Assessment: A Guide to Best Professional Practices*. CRC Press.
- EcclestonC.H,(2000), Effective Environmental Assessment, Lewis Publishers, London.

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Eranch Bharucha, (2005),Text book of Environmental Studies, University Grants Commission
Jane Holder and Maria Lee,(2007), Environmental Production, Law and Policies, Second Ediction.
JohnGlasson (2005), Introduction to Environmental Impact Assessment, Natural and Built Environment Series. Routledge, Taylor and Francis.
Khandeshwar S.R, Raman N.S,Gajbhiye A.R(2019). Environmental Impact Assessment. Dreamtech Press.
LarryW.Canter (2013),Environmental Impact Assessment, John Wiley and Sons. RamachandranS (2019). Environmental Impact Assessment. Airwalk Publications.
Singleton R, Castle Pand SortD (1999), Environmental Assessment, Thomas Telford Publishing London.
SureshK.Dhameja,(2005),Environmental Science and Engineering, Published by Sanjeev Kumar Kataria, Delhi.

</td></tr>
<tr><td>Outcomes</td><td>On successful completion of the course, students can
➢ Understand the scope of EIA
➢ Learn types and methods of EIA process
➢ Developed factors correlations kills
➢ Identify the role of EIA in sustainable environment management
➢ Improved the knowledge about EIA significance and magnitude
➢ Involved econometric values on level of impact
➢ Develope interaction matrix between variables
➢ Learn national and international protocols onEIA</td></tr>
</table>

Semester-III				
Course code: P23ES3P3	**Core Practical III**	**T/P**	**C**	**H/W**
	Lab-III: Biostatistics & Research methodology, Remote Sensing & GIS and EIA	**T**	**4**	**6**

Objectives

- The course deals with environmental audit, GIS data quality issues, GIS data analysis, integration and linkage of Remote Sensing and GIS besides including statistical tools used in research.

Biostatistical Applications

- Calculation of mean, median and mode,
- Calculation of standard deviation.
- Statistical Data Analysis–Mean, Standard Deviation, Standard Error.
- Statistical Data-Analysis of Variance (ANOVA).

Remote Sensing & GIS

- Preparation of simple Vector map, Toposheet reading and GPS field survey.
- Visual Interpretation of Geomorphic features from the Satellite image and Aerial photographs.
- Toposheet and Satellite Imagery Acquisition.
- Geo reference in toposheet /Satellite Imagery.
- Creation of Vector Layers.
- Raster Image Processing.
- Image Classification Techniques.
- Study area Map Representation/Creation.
- Comparative analysis of various mega building projects and its impact assessment.

EIA

- Remote Sensing and GIS in EIA assessment for Urban Development.
- Remote Sensing and GIS in EIA assessment for Landuse Land Cover Changes.

Air Monitoring

- Air pollution monitoring technique – SPM Gaseous Pollutants.
- Measurement of noise at different locations.

Reference and Textbooks:

- Arvind Shende and Vijay Upagade (2010).*Research Methodology*. S.Chand Publications.
- Charles H. Eccleston(2011).*Environmental Impact Assessment: A Guide to Best Professional Practices*. CRC Press.
- Gupta S.P.(2014).*Statistical Methods*. Sultan Chand & Sons Publications.
- MartinWegmann),Benjamin Leutner and Stefan Dech (2016). *Remote Sensing and GIS for Ecologists: Using Open Source Software (Datainthe Wild).*Pelagic Publication.

Outcomes	➢ On successful completion of the course, Students gain knowledge about mapping technology, concepts of maps and all relevant terminology which are necessary for a beginner to develop his skills in this new and upcoming technology.

Semester-III				
Course code P23ES3:A	**Elective V**	**T/P**	**C**	**H/W**
	Instrumentation & Analytical Techniques	**T**	**3**	**3**
Objectives	➢ The purpose of this course is to introduce knowledge and skills in analysis of environmental pollutants in environmental matrices, including extraction, sample preparation and instrumentations analysis, theory and techniques in quantitative And qualitative methods.			
Unit-I	Principles and application of Spectrophotometry-UV-Visible spectrophotometry, Spectro fluorimetry, Titrimetry, Gravimetry, Colorimetry, Infrared spectrophotometry, NMR, ESR, Microscopy-phase, light and fluorescence microscopes, Scanning and Transmission electron microscopes.			
Unit-II	Chromatographic techniques-Paper chromatography, thin layer chromatography, ion -exchange-chromatography, Column chromatography, Atomic absorption spectrophotometry, cytophotometry and flow cytometry, Fixation and staining, Principles and techniques of nucleic acid hybridization and Cot curves, Principle of bio physical method used for analysis of bio-polymer structure, Hydro dynamics methods, Plasma Emission spectroscopy.			
Unit-III	Electrophoresis, SDS- PAGE, Agarose gel electrophoresis, solid and liquid scintillation, autoradiography, X-ray florescence, Flame photometry, Gas-liquid chromatography, High pressure liquid chromatography, Ultracentrifugation			
Unit -IV	Conductometry, voltammetry, turbidimetry, pH meter, meteorological monitoring devices, portable gas analyzer, calorimeter, Neutron activation Analysis.			
Unit-V	Methods for measuring nucleic acid and protein interactions, DNA finger printing, Molecular markers RFLP, AFLP, RAPD, Sequencing of proteins and nucleic acids, southern, northern, western blotting techniques, PCR-polymerase chain reaction.			

Reference and Textbooks:

- Uppadahay,A., Uppadahay,N. and Nath,N.(2016),Bio physical Chemistry, Principles and Techniques, Himalaya Pub. House, NewDelhi.
- Sawyer, C.N., McCarty, P.L.and Parkin,G.F.(2002),Chemistry for Environmental Engineering and Science, McGraw-Hill Education
- Rupa,H.H.andKrist,H.(1998),Laboratory Manual for the Examination of Water, Wastewater and soil, VCH Publication, NewYork.
- Sharma,B.K.(2001),Instrumental Methods of Chemical Analysis, Goel Publishing House, Meerut, India.

Outcomes	The students on exposure to this course will be able to ➢ Understand the basics and requirement of environmental analysis ➢ Understand the environmental quality parameters to be monitored and determined ➢ Know the role of sample preparation in environmental analysis ➢ Understand the instrumental techniques and methods of analysis

Semester-III				
Course code P23ES3:B	**Elective V**	**T/P**	**C**	**H/W**
	ENVIRONMENTALEDUCATION	**T**	**3**	**3**
Objectives	➢ The course focuses on Introduction to basic principles of environmental health and safety practices and creating awareness of public and occupational health and safety requirements associated with the environment. The purpose of this course is to understand the role of environmental health, protection, safety at work, Occupational health and safety, compliance and best practices.			
Unit-I	**Definition, concept, policy, history and practices**: What is environmental education-Major requirements of environmental education-Inter disciplinary, Psychological, cultural and physical–Inter relatedness–Flexibility–Nondogmatic-Emphasis on problem solving-Practice what you preach-present status- : history, Primary level, secondary level, third level and training for professionals. Content of environmental Education-Philosophy and environmental ethics-Political sensitivities–Scientific ethic sand Bioethics in mangrove environment–Endangered species-Animal cruelty.			
Unit-II	**Role of institution**: Teachers preparation and curriculum development for environmental Education-Environmental education school level, Universities, R&D Institutions-Educationforphysicalplanners-Environmentalmanagementeducation –Teaching and learning strategies for environmental education-Role of non-governmental organization in Environmental Education–Role of regional, global organizations involved in living and non-living resources and its management programme.			
Unit- III	**Community and environmental education.** Coastal rural development- Women's role – poverty and environment – Population education and its relationship with environmental education- Environmental awareness among children of rural and non-formal education centres-Community based resource management. Environmental Hazards: Causes and effects of environmental hazards, effect of human activities on environment-environmental pollution - global and local (Soil pollution, water pollution, air pollution, noise pollution)-Green House effect–Ozone layer depletion–acid rain, pillar melting, rise of sea level and their implications-Mitigation efforts environmental prospective- International co-operation-Support Policies and systems.			
Unit -IV	**Mass media in environmental and eco- tourism :** Radio-Television–Newspapers–Cinema-Poster and Banners-Man media-Public interaction models-Evaluation of environmental education. Eco-tourism: Principle and concept–Ecotourism potential–Nature conservation–Training, education awareness through ecotourism-Community based resource management-Managing the protected area through ecotourism awareness. Conservation Strategy and policy statement on environment and development: Environmental problems-Action taken, Constraints and agenda for action-Development policies.			
Unit-V	**Sustainable Development and Environmental Awareness**- Learning to live in harmony with nature - environmental education for development, conservation of soil, water,f orests, wildlife, energy resources, movement to save environment, eco-friendly technology-Alternate sources of energy-Waste management-Population and environment.			

Reference and Textbooks:

- Canter,E.W.(1977):*Environmental Impact Assessment*. McGraw HillCo., NewYork Fedron,E. (1980): *Man and Nature*, Progress Publishers, Moscow
- Kormondy,E.(1991):*Concept of Ecology*,Prentice Hall of India, New Delhi.
- Odem, E.P. (1975): *Ecology*, Oxford and IBH Publishing Co.,New Delhi.
- Purdom, P.W . & Anderson: *Environmental Science*, Charles E. Merril Publishing Co.,
- Saxena,A.B.(1996):*Education for the Environmental Concerns*, Implications and Practices, Radha Publication, New Delhi.
- Sharma,P.D.(1993):*Environmental Biology*, Rastogi & Co., Meerut.

Outcomes	On successful completion of the course, the students get ➢ Knowledge in the concepts and scope, basic requirements for healthy environment, environmental quality, human exposure and health impact. ➢ Knowledge of the Industrial pollution and chemical safety in public exposure from industrial sources, Hazards by industry major chemical contaminants at work place. Industrial environmental accidents. ➢ Knowledge about Environmental Disease present study in Fluorosis and Allergies; Epidemiological issues. ➢ Knowledge of understand course will equip student with basic knowledge on safety issue related with explosion, pollutant release in water and air, and to Implement measure during outbreak of flu epidemic at workplace.

Semester-III				
Course code: P23ES3E1	**NMEC II**	**T/P**	**C**	**H/W**
	ECOTOURISM	**T**	**2**	**3**

Objectives	Recognize the importance of ecotourism, its components, impacts and management. Identify the environmental issues with tourism. Apply management practices towards sustainable ecotourism.
Unit-I	**Introduction to Tourism** Scope and definitions; Objectives of tourism; Significance of Tourism – Classification – Religious tourism – Cultural tourism – Heritage tourism – Monumental tourism – Adventure tourism – Mass tourism – Sustainable tourism – Consumptive & non consumptive tourism; implications of tourism.
Unit-II	**The Concept of Ecotourism** Ecotourism – definition and characteristic features - Ecosystem & biodiversity support to local economy, conservation of biosphere, learning experience; Goals - social, economical and environmental. Objectives of Ecotourism
Unit-III	**Impacts of Tourism on Environment** Principles of Ecotourism Types of Ecotourism — benefits of Ecotourism – trends affecting ecotourism - Economic impacts (fiscal impacts) – Socio cultural impacts – Environmental impact - Population growth and carrying capacity leading to environmental pressures – biophysical, socio psychological, resource exploitation, poor management, pollution and environmental disturbances
Unit -IV	**Management of Ecotourism** Development of information services, transport and accommodation – Regulation of funds (for operational facilities and administration) – Equitable management and distribution of resources and waste management – Eco certification, policies and regulations – Ecotels & Eco morals – Sustainable ecotourism.
Unit-V	**Ecotourism in India** Ecotourism in India - India - a land of pluralism: land, people, flora and fauna and climatic variations – biogeographic classification of India (10 regions) – Different ecotourism spots in India– Contrast from tropics to snow; land to ocean deep sea.

Reference book and Text Books

1. Bhatia AK, Tourism in India: Its History and Development (1978). Sterling Pub., New Delhi.
2. Bhatia AK, Tourism Developments: Principles & Practices (2002). Sterling Pub., New Delhi.
3. Ratandeep S, Dynamics of Modern Tourism (1998). Kanishka Pub., New Delhi.
4. Praveen S, Hand Book of Modern Tourism (1999). Ammol Pub., New Delhi.

Outcomes	Realize the importance of ecotourism, its components, impacts and management. Identify the environmental issues with tourism.

Semester-III				
Course code: P23ES3I1	**INTERNSHIP**	**T/P**	**C**	**H/W**
	INDUSTRY EXPOSURE AND INERNSHIP	**P**	**2**	**3**

Objectives	Minimum fifteen-days training in environmental concerns like NGOs, waste management facilities, industries or environmental testing centers and documentation.
Unit-I	**Industrial visits / Environmental Management Facility visits (40)** 1. **Theory** a. Introduction to industries b. Types of industries – Primary / secondary /tertiary c. Industry and environment 2. **Visit** Visits to any of the industries mentioned in Appendix I and documentation **Appendix I - Categories of visits** **1. Industries** a. A primary industry i. The extractive industries - mining of mineral ores, the quarrying of stone, and the extraction of mineral fuels b. A secondary industry- Manufacturing, energy-producing and construction industries i. Heavy or large-scale industry - petroleum refining, steel and iron manufacturing, motor vehicle and heavy machinery manufacture, cement production, nonferrous metal refining, meat-packing, and hydroelectric power ii. Light or small-scale industry – Low skilled - textile work and clothing, food processing, plastics manufacture, or highly skilled - electronics and computer hardware manufacture, precision instrument manufacture, gemstone cutting, and craft work
Unit-II	**2. Common waste management facilities** a. Biomedical waste management facility b. Municipal Solid waste management facility c. Sewage Treatment Plant d. Effluent Treatment Plant e. E Waste Management facility
Unit-III	**3. Environmental concerns** a. Environmental Laboratories b. Environmental Consultancy Agencies c. Non-Governmental Organizations etc. d. Eco-parks

Semester-IV				
Course code: P23ES408	**Core Course-VIII**	**T/P**	**C**	**H/W**
	OCCUPATIONALHEALTHHAZARDS ANDINDUSTRIALSAFETY	**T**	**5**	**6**
Objectives	The students on exposure to this course will understand the different types of hazards disasters possible in the industries. Focus has been made on the safety and management. Practiced in industries by highlighting certain case studies.			
Unit-I	**Health Hazards**: Physical Hazards–Noise, Risk Factors, Occupational Damage, Ionizing and Non-ionizing Radiation- Types and Effects, Hazards of Microwaves and Radio Waves, Lasers. Chemical Hazards – Introduction– Properties of Chemicals, Dust, Gases, Fumes, Mist, Vapours, Smoke and Aerosols. Route of Entry to Human System. Biological and Ergo nomical Hazards– Classification of Biohazardous Agents- Bacterial, Rickettsial, Chlamydial, Viral Fungal and Parasitic.			
Unit-II	**Health Disorders**: Occupational Diseases, Silicosis, Asbestosis, Pneumoconiosis, Siderosis, Anthracosis, Aluminosis, Byssinosis, Bagassosis and Anthrax. Heavy Metals -Lead, Nickel, Chromium and Manganese Toxicity, Gas Poisoning(CO,Ammonia,H_2S) –Their Effects and Prevention.			
Unit III	**Industrial Safety Measures**: First Aid–Principles, Rules and Training, Personal Protective Equipment's(PPE)-Respiratory and Non – Respiratory Devices, Maintenance of Machines and Equipment's, Fire Extinguishers–Types and Handling, Fire Detection and Alarm Systems, Water Spray Systems for Explosions.			
Unit IV	**Plans, Polices and Rules Related to Industrial Safety**: Threshold Limit Values (TLV),TheFactoriesAct,1948,International Labour Organization(ILO) Convention, Safety Health and Environment (SHE), BIS on Safety and Health 15001-2000, OSHA, OHSAS-18001.National Policy on Occupational Safety, Health And Environment At Work–Indian Electricity Act2003, Indian Explosive Act–1984. Hazardous Materials Transportation Rules.			
Unit V	**Case Studies:** Major Industrial Disasters in India-The Bhopal Gas Tragedy 1984, Chasnala Mining Disaster 1975, Jaipur Oil Depot Fire 2009, Korba Chimney Collapse 2009, Mayapuri Radiological Incident 2010, Bombay Docks Explosion 1994, Disasters in the Rest of the World– Spyros Disaster 1978, Oppau Explosion, Germany1921, Courrieres Mine Disaster, France1906, Chernobyl Disaster, Ukraine1986, Halifax Explosion, Canada 1917, Benxihu Colliery Explosion1942.			

Reference and Textbooks:

- DellaD.E.,and Giustina, (1996),Safety and Environmental Management, Van Nostr and Reinhold International Thomson Publishing Inc.
- GoetschD.L.,(1999),Occupational Safety and Health for Technologists, Engineers and Managers, Prentice Hall.
- Hommadi, A. H. (1989), Environmental and Industrial Safety, I.B.B Publication, New Delhi. Kolluru R. V, (1994), Environmental Strategies–Hand Book, Mc Graw Hill Inc., New York.
- Walsh,W and Russell,L,(1984),ABC of Industrial Safety, Pitma Publishing United Kingdom.

Outcomes	On completion of the course, students ➢ Apply knowledge of science in the management of Industrial safety and health. ➢ Identify industrial safety and health problems. ➢ Understand professional and ethical responsibility in safety management of industries. ➢ Learning to deal with the contemporary issues surrounding occupational safety and health. ➢ Learning techniques and control of hazardous substances. ➢ Recognize the need for a professional development in this field. ➢ Solve the problems related with industrial safety. ➢ Understand the impact of occupational safety and health

Semester-IV				
Course code: P23ES409	**Core Course-IX**	**T/P**	**C**	**H/W**
	CLIMATECHANGE	**T**	**5**	**6**
Objectives	➢ To impart the knowledge of fundamental scientific principles, concepts and global Perspective under lying climatic change.			
Unit-I	Climate change – concept of climate change –Atmosphere-atmospheric motion, Earth's rotation: Coriolis effect, global atmospheric circulation. Human Impacts on climate-green house gas emissions, Fossil---fuel emissions scenarios, IPCC. Green house effect; Water vapor and climate, Carbon cycle.sea level rise - Carbon pools and their relative significance. Ozone depletion-stratospheric ozone shield and Ozone hole–Impact of Climate Change on environment and biodiversity and their implications.			
Unit-II	Adaptation and Mitigation Responses and policies of climatic changes-Emissions trading/carbon credits chemes. International adaptation initiatives and programs-renewable energy, green building, energy efficiency and reducing consumption-low carbon economy. Integrated mitigation for development and planning through low emission development strategies - Climate Change and sustainable development. Role of Governments, Business, NGOs, other Institutions in adapting to and mitigating climate Change			
Unit III	The Climate Change Policy Framework- The Montreal Protocol-Provisions of the United Nations Framework Convention on Climate Change (UNFCCC) - structure of the UNFCCC, and different party groups under the convention -Annex I, Annex II and Non-Annex I countries. Paris agreement. The Kyoto protocol and its associated bodies. IPCC-Working group I workgroup II working group III.			
UnitIV	Social connection to climatic change: Climate change and Carbon credits-CDM-Initiatives in India. Climate justice, Immigration issues. Environmental movements; The classic case of earth day. Main climate change negotiations evolved over the past years and highlights of some key issues relevant to future climate change regime.			
UnitV	Climatic change and Socio-economic implications**:** Economic importance - drought and desertification-fishing and forestry-changes in monsoon pattern-industries-food productions-healthcare-tourism-transportation and energy consideration. Carbon tax and Emission trading, Green fiscal policy			

Reference and Textbooks:

- Botkin, D.B. and Keller, E.A.(2014),*Environmental Science*:EarthasaLivingPlanet,9th edition,J ohn Wiley & Sons,USA.
- Burroughs, W.J. (2007). *Climate Change: A Multidisciplinary Approach*. 2nd Edition.Cambridge University Press.
- Chasek,P.S.(2004),*The Global Environment in theTwenty-FirstCentury-Prospects for Internationa lCo-operation*, Manas Publications, NewDelhi.
- Climate Change: Science,Strategies and Solutions, Claussen, E.(2001),Arlington VA.
- Climate Change: *A Multidisciplinary Approach*, 2nd edition, Cambridge University Press. Dash,S.K .(2007),*Climate Change-An Indian Perspective*, Cambridge University Press India PvtLtd., New Delhi.
- Dodds,F.and Middleton,T.(2002),*Earth Summit*, a New Deal,Earthscan Publications Ltd.,UK.

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- Enger,E.D.andSmith,B.F.(2006),*Environmental Science*:A Study of Interrelationships. 11th edition, McGraw Hill Inc.,USA.
- Hardy,John,T.(2003),*Climate Change: Causes, Effects, Solutions* Wiley and Sons,USA.Ranade,P.S.(2008),
- *Climate Change and Biodiversity*: Perspectives and Mitigation Strategies- ICFAI University press.
- Ranade,P.S.(2008).*Climate Change and Biodiversity: Perspectives and Mitigation Strategies*. ICFAI University press.

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<tr><td>Outcomes</td><td>On completion of the course, students will be able
➢ To understand the environmental issues, energy systems, management related to climatic change
➢ Obtain in depth knowledge of effect of climatic change on global society
know the way in which society works with the effects of climate change and climate adaptation.</td></tr>
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Semester-IV				
Course code P23ES4:A	**Elective VI**	**T/P**	**C**	**H/W**
	NATURAL RESOURCE MANAGEMENT	**T**	**3**	**4**
Objectives	➢ The course deals with Waste treatment technologies for resource and energy Recovery to deliver value-added products.			
Unit-I	Forest-Forest types, role of forest, Forest products- demand and supply, Tribal and forest, Forest management. Classification of forest land, Administrative classification of forests, Classification of forests for management, social forestry, community forestry. Indian forest policy and Forest conservation. National Forestry Action Plan-1999: An Overview.			
Unit-II	Wildlife-Importance of wildlife, abuse and depletion of wildlife, Wildlife conservation-classification of scarce wildlife, Methods of wildlife conservation, Endangered species of India, Wildlife conservation in India, Legislation: WLPA – 1972 and 2002 Amendment, development and Impact of wildlife, National Parks and Sanctuaries, GO's and NGO's in Wildlife conservation, Eco-tourism.			
Unit-III	Energy-Energy requirement, Impact of energy utilization on the environment. Conventional sources of energy: Coal, Oil and Natural gas, Thermal power, Firewood, Hydropower, Nuclear power. Non-Conventional Sources of Energy: Solar energy, Wind energy, Ocean/ Tidal energy, Geothermal energy, Biomass energy, Dendro thermal energy, Energy from urban waste, Bagasse energy.			
Unit-IV	The nature of soil, characteristics and value. Soil formation, soil profile and soil classification. Soil fertility. Soil conservation and sustainable agriculture: nature of soil erosion; factors affecting soil erosion by water and its control. Alternative agriculture, sustainable agriculture. Land use and environmental problems of soil. Soil surveys and Land use planning.			
Unit-V	Water-Surface and groundwater, Water management, Rainwater harvesting, Water shed management. Aquaculture-Inland water resources and their economic potential with respect to fisheries. Freshwater fish culture, Establishment, and management of fish farm. Fishery–asself-employment avenue(smallscaleindustry), Govt.schemes,Trainingand incentives.			

Reference and Textbooks:

- SasikumarK(2009).*Solid Waste Management*. Prentice Hall India Learning Private Limited. PatwardhanA.D(2017).*Industrial Wastewater Treatment*. PHI Learning Publication.
- Ramanathan Jagbir SinghA.L(2019). *Solid Waste Management: Present and Future Challenges*. Dream tech Press.
- Pachauri,R.K.andSridharan,P.V.(1997),*Looking back to Think Ahead: Geen India* 2047, The Energy Research Institute, NewDelhi
- Murty,J.V.S.(2017),*Watershed Management*, New Age International Publishers
- Todd,T.KandMays,L.W.(2011),*Groundwater Hydrology*, Wiley.Agarwal,V.C.(2012),*Groundwate rHydrology*, PHILearning.
- Klee.G.A.(1991),*Conservation of natural resources*, Prentice Hall Publ.Co.,New Jersey.
- Owen.O.S.,Chiras,D.D.andReganold.J.P,(1998),*Natural resource conservation management for a sustainable future*,Prentice Hall.

Outcomes	➢ On completion of the course, students can understand the waste generation process and characteristics of different types of solid wastes and ability to apply recycle by resource recovery technologies for useful conversion of specific Waste type to eco-friendly products.

Semester-IV				
Course code P23ES4S1	**SEC**	**T/P**	**C**	**H/W**
	ECOSYSTEM VISIT AND ENVIRONMENTAL AUDIT	**T**	**2**	**4**

Objectives	➢ The course deals with Waste treatment technologies for resource and energy Recovery to deliver value-added products.
Unit-I	**DOMESTIC AND ENVIRONMENTAL AUDIT** **Water Audit-**Importance and objectives–Methodology–Assessment-Result and inference-Conservation measures **Energy Audit-**Importance and objectives–Methodology–Assessment-Result and inference-Conservation measures **Waste Audit-** Importance and objectives-Methodology Assessment-Result and inference–Conservation measures **Carbon footprint-** Carbon footprint calculation; Result and inference; Carbon offset measures
Unit-II	**ECOSYSTEM VISITS** Description of various ecosystems and conservation Areas Visits to any of the ecosystems as in Appendix I and documentation **Appendix I - Categories of visits** Conservation of Biodiversity - In-situ conservation a. Wildlife Sanctuaries b. National Parks c. Biosphere Reserves d. Conservation Reserves e. Community Reserves
Unit-III	Conservation of Biodiversity - Ex-situ Conservation a. Botanical gardens b. Medicinal garden c. Arboretum d. Zoological parks e. Aquaria f. Butterfly Park g. Crocodile bank
Unit-IV	Natural ecosystem biodiversity – Montane ecosystem a. Thorn forest b. Deciduous – dry/moist c. Evergreen Natural ecosystem biodiversity – Littoral forests a. Grassland b. Swamp c. Mangrove d. Dry evergreen
Unit-V	Manmade ecosystems a. Plantation Crops: Areca nut, Coffee, Tea, and cardamom b. Commercial Crops: Cotton, Sugarcane, Tobacco, Cashew nut c. Forest Plantation: Wattle, Eucalyptus, Acacia and Teak d. Food crops: Paddy, Wheat, Maize and Potato

Reference and Textbooks:

Text Books

1. Canter, L. W. Environmental Impact Assessment. McGraw Hill Book Co., New York,1977.

Reference Books

2. April Smith. Campus Ecology – A Guide to Assessing Environmental Quality and Creating Strategies for Change. Living Planet, LosAngeles,1993.
3. Rao, M. N and Rao, H. V. N. Air Pollution. Tata McGraw Hill Publishing Co. Ltd., New Delhi,1989.
4. Cunningham, A. B. Professional Ethics and Ethnobotanical Research. In: Alexiades M, Editor. Selected guidelines for Ethnobotanical Research: a field manual. Bronx: New York Botanical Garden; 1996.p.19–51.
5. Chapman, J. Land Reiss, M. J. Ecology-Principles and Applications.
6. Cambridge University Press (Low price edition), 1995.
7. Melchias, G. Biodiversity and Conservation. Oxford IBH. New Delhi.
8. 236Pp, 2001.
9. Levin, S. A. Encyclopedia of Biodiversity: Second Edition. Academic Press 5 Vols,2000.
10. Singh, J. S., Singh, S. P and Gupta, S. R. Ecology, Environment and Resource Conservation. Anamaya Publ., New Delhi. 688 Pp,2006.

Web Link

1. http://old.cwc.gov.in/main/downloads/DraftGuideline_Water_Audit.pdf
2. https://www.adb.org/sites/default/files/publication/28555/estimating-carbon-footprints-road-projects.pdf
3. https://nptel.ac.in/content/storage2/courses/105103025/pdf/pdf3.pd
4. https://www.youtube.com/watch?v=Z8jOcYEtyc0
5. https://nptel.ac.in/content/storage2/courses/105105110/pdf/m3l03.pdf
6. https://dducollegedu.ac.in/Datafiles/cms/ecourse%20content/PK%20(AECC-EVS)%20Chapter%20-%204%20Biodiversity.pdf