

**M.Sc.,  
ENVIRONMENTAL SCIENCE**

**SYLLABUS**

**FROM THE ACADEMIC YEAR  
2023 - 2024**

**TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,  
CHENNAI - 600 005**

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

	<p><b>PSO3 – Research and Development</b> Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.</p> <p><b>PSO4 – Contribution to Business World</b> To produce employable, ethical and innovative professionals to sustain in the dynamic business world.</p> <p><b>PSO 5 – Contribution to the Society</b> To contribute to the development of the society by collaborating with stakeholders for mutual benefit.</p>
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**Template for P.G., Programmes**

Semester-I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester-IV	Credit	Hours
1.1. Core-I	5	7	2.1. Core-IV	5	6	3.1. Core-VII	5	6	4.1. Core-XI	5	6
1.2 Core-II	5	7	2.2 Core-V	5	6	3.2 Core-VII	5	6	4.2 Core-XII	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	6	3.3 Core – IX	5	6	4.3 Project with viva voce	7	10
1.4 Discipline Centric Elective -I	3	5	2.4 Discipline Centric Elective – III	3	4	3.4 Core – X	4	6	4.4Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Generic Elective-II:	3	5	2.5 Generic Elective -IV:	3	4	3.5 Discipline Centric Elective - V	3	3	4.5 Skill Enhancement course / Professional Competency Skill	2	4
			2.6 NME I	2	4	3.6 NME II	2	3	4.6 Extension Activity	1	
						3.7 Internship/ Industrial Activity	2	-			
	<b>20</b>	<b>30</b>		<b>22</b>	<b>30</b>		<b>26</b>	<b>30</b>		<b>23</b>	<b>30</b>
<b>Total Credit Points -91</b>											

**Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework  
(LOCF) Guideline Based Credits and Hours Distribution System  
for all Post – Graduate Courses including Lab Hours**

**First Year – Semester – I**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		<b>20</b>	<b>30</b>

**Semester-II**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course [SEC] - I	2	4
		<b>22</b>	<b>30</b>

**Second Year – Semester – III**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity [Credits]	2	-
		<b>26</b>	<b>30</b>

**Semester-IV**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		<b>23</b>	<b>30</b>

**Total 91 Credits for PG Courses**

**M.Sc., ENVIRONMENTAL SCIENCE**  
**Programme Structure**

S.No	Courses	Title of the Paper	T/P	Credits	Hours/ Week	Marks		
<b>I-Semester</b>						<b>I</b>	<b>E</b>	<b>Total</b>
1	Core 1	Principles of Ecology	T	5	7	25	75	100
2	Core 2	Environmental Pollution	T	5	7	25	75	100
3	Core 3	Lab-I: Ecological Methods, Environmental Pollution and Environmental Chemistry	P	4	6	25	75	100
4	Elective 1	Environmental Chemistry	T	3	5	40	60	100
5	Elective 2	Disaster Management/ Environmental Laws and Policies	T	3	5	25	75	100
				<b>20</b>	<b>30</b>			
<b>II-Semester</b>								
6	Core 4	Environmental Microbiology	T	5	6	25	75	100
7	Core 5	Environmental Biotechnology	T	5	6	25	75	100
8	Core 6	Lab-II: Environmental Microbiology, Biotechnology and Toxicology	P	4	6	25	75	100
9	Elective 3	Environmental Toxicology	T	3	4	40	60	100
10	Elective 4	Bioremediation/ Biodiversity and Conservation	T	3	4	25	75	100
11	SEC-I	Skill Enhancement Course – I	T	2	4	25	75	100
				<b>22</b>	<b>30</b>			
<b>III-Semester</b>								
12	Core 7	Biostatistics & Research Methodology	T	5	6	25	75	100
13	Core 8	Remote Sensing & GIS	T	5	6	25	75	100
14	Core 9	Environmental Impact Assessment	T	5	6	25	75	100
15	Core 10	Lab-III: Biostatistics, Remote sensing and GIS and EIA	P	4	6	40	60	100
16	Elective 5	Instrumentation & Analytical Techniques/ Environmental Education	T	3	3	25	75	100
17	SEC-II	Skill Enhancement Course – II	T	2	3	25	75	100
		Internship / Industry Activity		2	-			
				<b>26</b>	<b>30</b>			

IV-Semester									
18		Core 11	Occupational Health Hazards & Industrial Safety	T	4	4	25	75	100
19		Core 12	Climate Change	T	4	4	25	75	100
20		Project	Project work with Viva Voce						
21		Elective 6	Natural Resource Management	T	4	4	25	75	100
		SEC-III	Skill Enhancement Course – III / Professional Competency Skill		2	4			
		Extension Activity				1	-		
<b>Total</b>					<b>23</b>	<b>30</b>			
					<b>91</b>				

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<b>Semester-I</b>				
<b>Coursecode:</b> 22MES1C1	<b>CoreCourse-1</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>PrinciplesofEcology</b>	<b>T</b>	<b>4</b>	<b>5</b>
<b>Objectives</b>	➤ 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 four environment, ecology and also about environmental issues and its sustainability.			
<b>Unit-I</b>	Definition, principles and scope of ecology, human ecology and human settlements, evolution, origin of life and speciation, Ecosystem stability-cybernetics and ecosystem regulation, Concept of Ecosphere and Biosphere, evolution of biosphere.			
<b>Unit-II</b>	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 – Freshwater pond, Wetlands, Beels, Rivers – their characteristics, flora and fauna; Marine Habitats – Pelagic, Benthic, Inter-tidal Estuarine; Mangroves – their characteristics, flora and fauna.			
<b>Unit- III</b>	Ecosystem structure and functions, abiotic and biotic component, Energy flow, food chain, food web, Ecological Pyramids - types, biogeochemical cycles, Community Ecology: Definition and concept of community, community diversity, structure, dominance, stratification and periodicity. Ecads and ecotypes, Edge effect and Ecological Niche, ecological succession - characteristics, types of succession, concept of climax, significance of succession.			
<b>Unit-IV</b>	Population ecology - density, natality, mortality, survivorship curves, age distribution, growth curves and models, r & k selection, population interactions - Neutralism, symbiosis, commensalism, Mutualism, antagonism, antibiosis, Parasitism, Predator-Prey relations, Competition – intra-specific and inter-specific, System Theory and Ecological Model.			
<b>Unit-V</b>	Environmental Microbiology - concept and definitions; microbes in agriculture - soil microorganism and their functions, biological nitrogen fixation, bio-fertilizers, mycorrhiza; coastal management, criteria employed for disposal of pollutants in marine ecosystem, coastal water system and man-made reservoirs, biology and ecology of reservoirs.			
<b>Reference and Textbooks:</b>				
Eugene P. Odum (2017). <i>Ecology</i> . Oxford and IBH Publishing Co. Pvt. Ltd.				
Manuel Molles (2015). <i>Ecology: Concepts and Applications</i> . 7 <sup>th</sup> Edition. McGraw-Hill Education.				
Pratibha Singh, Anoop Singh & Piyush Malaviya (2009) <i>Text Book of Environment &amp; Ecology</i> – Excel Publishers.				
Rana S. V. S. (2009) <i>Essentials of Ecology and Environmental Science</i> . Prentice Hall Publishers Ltd.				
Sharma P. D. (2012). <i>Ecology and Environment</i> . Rastogi Publications				
<b>Outcomes</b>	<p>Upon successful completion of the course, the student can</p> <ul style="list-style-type: none"> <li>➤ Understand the principles, scope and components of the earth and environment</li> <li>➤ Know the basic concept of ecology and ecosystems, factors and its interaction along with its succession processes</li> <li>➤ Understand the concept of biodiversity, its types, values and its conservation methods</li> <li>➤ Learn about various environmental issues and environmental sustainability.</li> <li>➤ Apply the knowledge of basic ecology in field studies.</li> <li>➤ Understand the interrelation between the earth environment and man</li> </ul>			



Semester-I					
Coursecode: 22MES1C2	CoreCourse-2		T/P	C	H/W
	EnvironmentalPollution		T	4	5
<b>Objectives</b>	<ul style="list-style-type: none"> <li>➤ To get deeper insights into fundamentals of water, air and soil pollution, monitoring and analysis of environmental pollution</li> <li>➤ To realize, monitor and analyse the impacts of pollution, environmental problems and its control measures.</li> </ul>				
<b>Unit-I</b>	<p>Concepts of atmosphere and Air Pollutants (Sources and classifications- indoor, vehicular, industrial and other sources). Meteorological 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, Wet scrubber, Control of gaseous pollutants absorption, adsorption and combustion recovery system) – online monitoring of pollution.</p>				
<b>Unit-II</b>	<p>Properties of water; physiochemical and bacteriological properties of water, drinking water quality standards; Water pollution- Classification (ground water, river, Marine) sources and sinks, Eutrophication. Control measures of water pollution (adsorption, flocculation, ion exchange and reverse osmosis). Preventive measures in industries to avoid water pollutions (End of pipe treatments and its alternatives, online monitoring and treatment of industrial effluents).</p>				
<b>Unit- III</b>	<p>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 impacts on physio-chemical and biological properties of soil and plants, Sediment Pollution – Black carbon – Soil pollution control measures – On site (in situ) chemical, physical, soil vapour extraction, soil washing solidification/stabilization, electro-kinetic remediation thermal and biological methods. Off site (ex-situ, on-site and off-site) chemical methods, Physical solidification/stabilization/immobilization, thermal, and biological (bioremediation and phytoremediation), Biostimulation, Bioaugmentation, Isolation containment of the affected area.</p>				
<b>Unit -IV</b>	<p>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 reactors 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.</p>				
<b>Unit-V</b>	<p>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.</p>				

**ReferenceandTextbooks:**

AhluwaliaV.K (2014).*EnvironmentalPollutionandHealth*.TheEnergyandResourcesInstitute,TERI

AvinashChauhan(2020)*EnvironmentalPollutionandManagement*.IKInternationalPublishersLtd

GuptaO.P(2019).*ElementsofEnvironmentalPollutionControl*.KhannaPublication.

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<p>Mark Brusseau, Ian Pepper, Charles Gerba (2019) <i>Environmental and Pollution Science</i>, 3rd Edition, Academic Press</p> <p>Rao, C.S. (2018). <i>Environmental Pollution Control Engineering</i>, 3<sup>rd</sup> Edition. New Age International Publication.</p> <p>Shafi, S.M (2005) <i>Environmental Pollution</i>. Atlantic Publishers and Distributors.</p>	
<b>Outcomes</b>	<p>On successful completion of the course,</p> <ul style="list-style-type: none"><li>➤ The students will be able to understand the basic principles and fundamentals of Air/Soil/Water pollutants and their impact on environment.</li><li>➤ Students will be able to gain detailed knowledge on local and global environmental issues and analyze chemical processes involved in different environmental problems.</li></ul>

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<b>Semester-I</b>				
<b>Coursecode:</b> 22MES1C3	<b>CoreCourse-3</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>EnvironmentalChemistry</b>	<b>T</b>	<b>4</b>	<b>5</b>
<b>Objectives</b>	<ul style="list-style-type: none"> <li>➤ Thecourseintroducestheconceptand scope of environmental chemistry includingsoilchemistry,chemicalcompositionofairandwatertreatmenttechnologies.</li> <li>➤ Thecoursealsodevelop anunderstanding ofbasicsofchemistry inrelevancetoenvironment and such as,solutions preparation,chemical reactions and their effectsontheenvironment,toprovidestudentswithanunderstandingofthefundamental chemicalprocessesoccurredonenvironment.</li> </ul>			
<b>Unit-I</b>	ConceptandscopeofEnvironmentalChemistry;acidbasereactions,Stoichiometry,Gibb'senergy,Chemicalpotential,Chemicalequilibria,acid-base.reactions.Solubilityproduct,solubilityofgasesinwater,thecarbonatesystem,unsaturatedand saturated hydrocarbons,Radionuclides.			
<b>Unit-II</b>	Classificationofelements,chemicalspeciation,Particles,ionsandradicals inthe atmosphere.Chemicalprocessesforformationofinorganicandorganicparticulatematter.Thermochemicalandphotochemicalreactionsintheatmosphere.			
<b>Unit- III</b>	Firstlawofthermodynamics,enthalpy,adiabatictransformations,secondlawofthermodynamic s, Carnot's cycle, entropy, Gibb's free energy, chemical potential, phaseequilibria,Gibb'sDonnanequilibrium,thirdlawofthermodynamics,enzymescatalysis, Michaelis/Mentenequation.			
<b>Unit -IV</b>	Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical Smog Chemistry of water, concept of D.O., B.O.D., and C.O.D, watertreatment:Sedimentation,Coagulation,Filtration,tertiaryandadvancedtreatment,redoxpotential.			
<b>Unit-V</b>	SoilChemistry-Chemicaland mineralogicalcompositionofsoil,Physicalpropertiesofsoil – texture, bulk density, permeability; Chemical properties – cation exchange capacity,pH,macroandmicronutrients.Chemicalcompounds- detergentsandbleachingagents,Hydrocarbons,PAH,PCBs,chlorofluorocarbons,pesticides.			

**Reference and Textbooks:**

Balram Pani, (2007) *Text Book of Environmental Chemistry*, I.K. International Publishing House PVT. Ltd.

Dara S, Mishra D.D (2006). *A Textbook of Environmental Chemistry and Pollution Control*. S. Chand Publication.

Gary W. Van Loon, Stephen J. Duffy (2017). *Environmental Chemistry: A global perspective*. 4<sup>th</sup> Edition. OUP Oxford.

Girard J.E. (2015) *Principles of Environmental Chemistry*.

Julian E. Andrews, Peter Brimblecombe, Tim D. Jickells, Peter S. Liss, Brian Reid (2013). *An Introduction to Environmental Chemistry*. Wiley-Blackwell Publication.

Rao, C.S. (2018) *Environmental Pollution Control Engineering*, 3rd Edition, New Age International (P) Ltd Publishers.

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<b>Outcomes</b>	On successful completion of the course, the students <ul style="list-style-type: none"><li>➤ Have knowledge of basic theories and problems of Environmental chemistry</li><li>➤ Describe important chemical reactions and cyclic processes of chemical species in the atmosphere, hydrosphere and lithosphere</li><li>➤ Demonstrate knowledge of chemical principles of various fundamental environmental phenomena</li><li>➤ Apply basic chemical concepts in understanding the behavior of pollutants</li><li>➤ Analyze chemical processes involved in air, water and soil environmental problems</li><li>➤ Know the different types of toxic and hazardous substances and analyze their toxicological information</li></ul>
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<b>Semester-I</b>				
<b>Coursecode:</b> 22MES1P1	<b>CoreCourse-4</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>Lab-I:EcologicalMethods,EnvironmentalPollutionand EnvironmentalChemistry</b>	<b>P</b>	<b>4</b>	<b>8</b>
<b>Objectives</b>	<p>➤ The course demonstrates concepts in modern ecology, methods to analyze pollution and environmental applications.</p> <ol style="list-style-type: none"> <li>1. Biotic and Abiotic Component Assessment</li> <li>2. Primary productivity of an aquatic ecosystem</li> <li>3. Estimation of GPP and NPP</li> <li>4. Field Survey and Sampling Methods</li> <li>5. Ecological Data Collection</li> <li>6. Ecological Data Interpretation and Presentation</li> <li>7. Air Pollution Monitoring Techniques – SPM, Gaseous Pollutants.</li> <li>8. Measurement of noise at different locations.</li> <li>9. Soil sampling techniques and devices</li> <li>10. Selection of sampling sites and collection of methods of samples</li> <li>11. Determination of EC, turbidity, odour and colour in water</li> <li>12. Determination of TS, TDS and TSS in water</li> <li>13. Determination of Acidity and alkalinity in water</li> <li>14. Determination of DO, BOD, COD and pH in water</li> <li>15. Determination of Hardness in potable water</li> </ol>			
<b>Reference and Textbooks:</b>				
<p>Barani Tharan Balamurali S (2016). <i>Environmental Engineering Laboratory Manual</i>: CreateSpace Independent Publishing Platform.</p> <p>Khopkar S.M. <i>Environmental Pollution Analysis</i>. New Age International (P) Ltd., Publication. Darrell S.</p> <p>Vodopich (2009). <i>Ecology Lab Manual</i>. McGraw Hill.</p> <p>Gopalan R (2020). <i>A Laboratory Manual for Environmental Chemistry</i>. Dreamtech Press.</p>				
<b>Outcomes</b>	<p>On the successful completion of the course, students will be able to</p> <p>➤ Students gain ability to set up basic and advanced ecological sampling techniques in different ecosystems.</p>			

<b>Semester-I</b>				
<b>Coursecode:</b> 22MES1E1	DSE-I A	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>DISASTERMANAGEMENT</b>	<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	<p>➤ To Understand basic concepts in Disaster Management &amp; mitigation, Definitions and Terminologies used in Disaster Management, understand various types of Disasters and to understand Impacts of Disasters and Risk Management.</p>			
<b>Unit-I</b>	<p>Definition–Hazards as natural process- Benefits and importance of disasters Nature of 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 man-made structures.</p>			
<b>Unit-II</b>	<p>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, Causes and preventive measures. Impact on Environment Forecasting and Warning System– Disaster Profile of India.</p>			
<b>Unit- III</b>	<p>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 Geographic Information system in Disaster Management.</p>			
<b>Unit -IV</b>	<p>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.</p>			
<b>Unit-V</b>	<p>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.</p>			



**Reference and Textbooks:**

David R. Godschalk, *Natural Hazard Mitigation: Recasting Disaster Policy and Planning* (Editor), Timothy Beatley, Phillip Berke, David J. Bowe, Edward J. Kaiser, Charles C. Bohl, R. Matthew Goebel, Island Press: (January 1999), ISBN 1559636025

Natural Disaster Management, Tudor Rose, 6 Friar Lane Leicester LE15 1RA United Kingdom. Jeff Gromann (2002) *The Atlas of Natural Disasters* by (Author) Publisher: Friedman/Fairfax 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. <i>Disaster Management: A Disaster Manager's Handbook</i> , Asian Development Bank, Manila. (1992).	
Gautam Ashutosh 1994. <i>Earthquake: A Natural Disaster</i> . Ashok Publishing House. New Delhi.	
Singh R. B. 2006 <i>Natural Hazards and Disaster Management; Vulnerability and Mitigation</i> . Rawat Publications.	
Jochen Zschau, Andreas N. Koppers (2003). <i>Early Warning Systems for Natural Disaster Reduction</i> . Springer-Verlag, Berlin Heidelberg.	
<b>Outcomes</b>	On the successful completion of the course, students will be able to <ul style="list-style-type: none"> <li>➤ Understand the Emergency/Disaster Management Cycle.</li> <li>➤ Develop a basic understanding of Prevention, Mitigation, Preparedness, Response and Recovery</li> </ul>

<b>Semester-I</b>					
<b>Coursecode:</b> 22MES1E2	DSE-IB		<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>ENVIRONMENTAL LAWS AND POLICIES</b>		<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	➤ To impart knowledge about environmental laws, regulations and policies of India and international environmental laws.				
<b>Unit-I</b>	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 basins system				
<b>Unit-II</b>	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 environmental laws. Case studies for International environmental disputes.				
<b>Unit- III</b>	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 interest litigation, class action, freedom of information and the right to know.				
<b>Unit -IV</b>	Indian legislation to protect the environment: The water act of 1974, The Water Cess act of 1977, The wildlife Act of 1972, the air act of 1981, The public Liability insurance act of 1991, the natural environmental tribunal act of 1995, the national environment appellate authority act of 1997, the mines and minerals act of 1957. Case studies on each in the protection of forests, rivers and wildlife.				
<b>Unit-V</b>	The Indian forest act of 1927, the forest (conservation) act of 1968, The atomic energy act of 1962, The factories act of 1948. The environmental protection act of 1986, The national environment appellate authority act of 1997. The forest conservation act 1980, The wildlife protection act 1972 (2002 amendment), - Plastics Waste management Rules 2015				
<b>Reference and Textbooks:</b>					
Gurudeep Singh (2005) <i>Environmental law in India</i> – McMillan, New Delhi.					
Shyam Diwan and Armin Rosencrany, 2001, <i>Environmental law and policy in India</i> , Oxford University Press, New Delhi.					
<i>Pollution Control Legislations</i> , Vol. I and II, 1999, Tamil Nadu Pollution Control Board, Chennai.					
Nath B., Hens, L., Compton, Pand D. Devuyt (1998), <i>Environmental Management in Practice</i> , Vol II, Routledge, London and New York.					
The ISO 14000 Handbook: Joseph Cascio. ISO 14004 –					
<i>Environmental management systems: General guidelines on principles, systems and supporting techniques</i> (ISO 14004: 1996(E)). ISO 14001: <i>Environmental management systems: Specification with guidance for use</i> (ISO 14001: 1996b(E)). (International organization for standardization – Switzerland).					

<b>Outcomes</b>	On the successful completion of the course, students will be able to <ul style="list-style-type: none"><li>➤ Understand environmental legislation and policies of national and international regime.</li><li>➤ Have an insight into major acts and rules applicable for pollution control and natural resource conservation.</li></ul>
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	<ul style="list-style-type: none"><li>➤ developtheskillsneededforinterpretinglaws,policiesandjudicialdecisionsabouttheenvironment.</li><li>➤ Knowregulationsapplicabletoindustriesandotherorganizationswithsignificantenvironmentalaspects.</li><li>➤ Applythelegislationconceptsfor-solvingthelocalenvironmentalproblems.</li><li>➤ GetknowledgeofthelégalsystemoperatinginIndia.</li><li>➤ Beinapositiontopreparecompliance reportsforgettingenvironmentalclearance</li><li>➤ Preparetheenvironmentalmanagementsystemforanorganization.</li></ul>
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<b>Semester-II</b>				
<b>Coursecode:</b> 22MES2C1	<b>CoreCourse-5</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>EnvironmentalMicrobiology</b>	<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	This course is designed to provide a basic understanding on microbiology and in-depth knowledge of role of beneficial and pathogenic microorganism in environment.			
<b>Unit-I</b>	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.			
<b>Unit-II</b>	Diversity of environmental microbes – Distribution – microbiology of aquatic environment (fresh, marine and other aquatic environment), microbiology of terrestrial environment. Aeromicrobiology – outdoor and indoor, aerosols, Adaptation of microorganisms to the air environment; extremophiles (archaeobacteria, acidophilic, alkalophilic, thermophilic, barophilic and osmophilic and radiodurant microbes).			
<b>Unit III</b>	Role of microorganisms in natural system and artificial system; Influence of Microbes on the Earth's Environment and Inhabitants; interspecies microbial interactions, Ecological impacts of microbes, Symbiosis (Nitrogen fixation and ruminant symbiosis); microbial interactions in biofilm, Plant – Microbe interaction (Beneficial and pathogenic), animal – microbe interactions (Beneficial and pathogenic) Role of Microorganism in Nutrient cycles.			
<b>Unit IV</b>	Bioindicator organisms in Environment – air, water and soil (Bacteria, algae, bacteriophages and other organisms). Standard criteria of indication, Bio-indication of water quality (surface and groundwater) – Coliforms – total coliforms, E-coli, Streptococcus, Clostridium, Concentration and detection of virus. Microbial pathogenesis (Human, Animal and Plant health), Transmission of pathogens to higher organisms – Bacterial, Viral, Protozoan, and Helminths, Control of microorganisms.			
<b>Unit V</b>	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).			
<b>Reference and Textbooks:</b>				
Bertrand, J- C., Caumette, P. and Lebaron, P. (2015), <i>Environmental Microbiology: Fundamentals and Applications: Microbial Ecology</i> , Springer.				
Jjemba, P.K. (2004), <i>Environmental Microbiology: Principles and Applications</i> , Science Publishers Inc., Enfield.				
Maier, R., Pepper, I. and Gerba, C. (2008), <i>Environmental Microbiology</i> , Academic Press. Mitchell, R. (2009), <i>Environmental Microbiology</i> , 2 <sup>nd</sup> edition, Wiley- Blackwell.				
Mohapatra, P.K. (2008), <i>Textbook of Environmental Microbiology</i> , I.K. International (P) Ltd.				

<p>Pepper, I.L., Gerba, C.P. and Gentry, T.J. (2015), <i>Environmental Microbiology</i>, 3rd edition, Academia Press, Elsevier.</p> <p>Schmidt, T.M. and Schaechter, M. (2012), <i>Topics in Ecological and Environmental Microbiology</i>, 3rd edition, Academia Press, Elsevier.</p> <p>Uhrig, B. (2017), <i>Environmental Microbiology</i>, Lulu.com Publisher.</p>	
<b>Outcomes</b>	<p>On successful completion of the course, the students</p> <ul style="list-style-type: none"> <li>➤ understand basic of microbiology and recent developments in environmental microbiology.</li> </ul>

<b>Semester-II</b>				
<b>Coursecode:</b> 22MES2C2	<b>CoreCourse-6</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>EnvironmentalBiotechnology</b>	<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	<ul style="list-style-type: none"> <li>➤ The course introduces knowledge of biotechnological approaches and techniques for Environmental management and remediation of various environmental pollutants.</li> <li>➤ impart knowledge of biotechnological approaches and techniques for Environmental management and remediation of various environmental pollutants.</li> </ul>			
<b>Unit-I</b>	<b>Emerging technology for bioremediation-</b> Restriction endonucleases Recombinant DNA Technology, techniques of restriction mapping- vectors- plasmid PBR322 and $\lambda$ phage, cosmid construction of chimeric DNA, Genomic and cDNA libraries- Polymerase Chain Reaction (PCR) and development of gene probes for environmental remediation. use of genetically altered microorganisms for field biodegradation of hazardous materials. In situ technologies, Ex-situ technologies. Suicide genes. Micro-electromechanical systems (MEMS), Genosensor technology.			
<b>Unit-II</b>	<b>Microbial biodegradation-</b> 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, phytoremediation.			
<b>Unit- III</b>	<b>Biotechnology for Resource Management-</b> New Bioremediation Technologies to Remove Heavy Metals and Radionuclides; Oilfield 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.			
<b>Unit -IV</b>	<b>Industrial Biotechnology-</b> Fermentation Technology- Design of Immobilized Enzyme Reactors – Packed – bed, Fluidized – bed and Membrane reactors- Application and advantages. Applications of Enzymes food, health, and other industries. in Design of enzyme electrodes and their application as biosensors in industry, health care and environment <b>Agricultural biotechnology-</b> Evolution in Agriculture- Biotechnology and Sustainable Production. (biofertilizers – Rhizobium, Azolla; Biopesticides – Bt insecticide.) modern agriculture- strategies for engineering herbicide- Resistance environment impact. Advantages and applications of biofertilizers, biopesticides and GM crops. <b>Forestry and Biotechnology-</b> micro-propagation; Somaclonal variations; Induction of genetic variability and heritability; Conservation of endangered species; Biotechnology in preservation of bio-diversity; In situ and ex situ conservation through gene banks.			



<b>Unit-V</b>	<b>Bioethics, Biosafety and IPR - Bioethics</b> – ethical concerns of biotechnology research and innovation of Genetically modified plants, animals and microbes, genetically modified food, stem cell research. Potential effect on Environment and Human health by transgenic plants-Risk assessment, regulation and containment - Human genome project - ICMR Ethical Guidelines for Biomedical Research on Human Subjects. Objectives and salient features of Biosafety guidelines and regulations-Rights Intellectual property rights-TRIP-GATT-Plant variety protection.
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<b>Reference and Textbooks:</b> Chatterji A.K.(2011). <i>Introduction to Environmental Biotechnology</i> . Prentice Hall India Learning Private Limited. Evano, G.H. and Furlong, J.C.(2004), <i>Environmental Biotechnology – Theory and Application</i> , John Wiley and Sons, USA. Gareth M. Evans, Judith C. Furlong (2012). <i>Environmental Biotechnology – Theory and Application</i> . 2 <sup>nd</sup> Edition. Wiley India Pvt Ltd. Jjemba, P.K.(2004), <i>Environmental Microbiology – Theory and Application</i> , Science Pub. Inc., USA. Olguin, C.J., Sanchez, G. , Hernandez. E.(2000), <i>Environmental Biotechnology and Cleaner Bioprocesses</i> , Taylor & Francis. Pepper, I.L. and Gerba, C.P.(2005), <i>Environmental Microbiology-Laboratory Manual</i> , Elsevier, USA. Ratledge, C. and Kristiansen, B.(2003), <i>Basic Biotechnology</i> , 2 <sup>nd</sup> edition, Cambridge University Press. Viswanath Buddolla (2017). <i>Environmental Biotechnology: Basic Concepts and Applications</i> . Alpha Science International Ltd	
<b>Outcomes</b>	On successful completion of the course, the students <ul style="list-style-type: none"> <li>➤ Will obtain the knowledge of Existing and emerging biotechnological approaches in remediation of pollution and environmental management.</li> <li>➤ Implement various practical approaches to address environmental issues relevant to environmental biotechnology.</li> </ul>

Semester-II				
Coursecode:	CoreCourse-7	T/P	C	H/W
22MES2C3	Environmental Toxicology	T	4	4
<b>Objectives</b>	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 pollutant in biological and Environmental systems is also included.			
<b>Unit-I</b>	<b>Introduction to Toxicology and Toxicants:</b> 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 <sub>3</sub> ), Organic contaminants (Hydrocarbons and PCBs) – Organochlorine insecticides (DDT and Aldrin), Organophosphorus insecticides (Parathion, Carbomates and Pyrethroids). Detergents, Pharmaceuticals and Personal Care Products.			
<b>Unit-II</b>	<b>Entry, Distribution and Mode of Action:</b> Routes of Entry – Inhalation, Absorption, Ingestion, Injection. Biodistribution, Biomagnification and Biotransformation. Types of Toxicity – Acute, Subacute and Chronic. Effects of Toxicants – Short Term and Long term. Dose Response Relationship – LC <sub>50</sub> , LD <sub>50</sub> , EC <sub>50</sub> . OSHA Permissible Exposure Limits (PELS). Mode of Action – Reactions of Toxicants with Target Molecules – Covalent Binding, Non-covalent Binding, Hydrogen Abstraction, Electron Transfer and Enzymatic Reactions.			
<b>Unit III</b>	<b>Systemic Toxicology I:</b> 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.			
<b>Unit IV</b>	<b>Systemic Toxicology II:</b> Neurotoxicants and Effects (Neuronopathy, Axonopathy). Effect of Toxicants on Reproductive and Cardiovascular System. Endocrine Disrupting Chemicals and their Toxicity. Immunotoxicants – Mechanisms of Immunotoxicity, Immuno-suppression, Direct and indirect Effects of Toxicants, Immune Mediated Diseases, (Hypersensitivity and Allergy)			

<b>Unit V</b>	<b>Ecotoxicogenomics, Toxicity Testing and Risk Assessment of Toxicants:</b> Introduction to Toxicogenomics, Toxicoproteomics and Metabolonomics-Modification of DNA, RNA and Protein Metabolism by Toxicants. Gene Expression Changes by Toxicants- Role of Ecotoxicogenomics for Environmental Monitoring and Toxicant Identification. Toxicity Testing Methods- Microbiol, Algal, Invertebrates and Alternative Toxicity Tests, Animal Management in Toxicological Evaluation- Extrapolation and Ethics. 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.
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**ReferenceandTextbooks:**

- Bertrand, J.C, Caumette, P. and Lebaron, P (2015). *Environmental Microbiology: Fundamentals and Applications: Microbial Ecology*. Springer publications.
- C.H. Walker, S.P. Hopkin, R.M. Sibly and D.B. Peakall, (2006), *Principles of Ecotoxicology*, Third Edition, CRC Press (Taylor & Francis Group).
- Daniel A. Vallero, (2005), *Environmental Contaminants- Assessment and Control*, Academic Press.
- David J. Hojman, 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 & Francis Group).
- 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*. 3<sup>rd</sup> Edition, Academia Press.
- Robert Burke, (2000), *Hazardous Materials Chemistry for Emergency Responders*, Lewis Publishers.
- Schmidt, T. M. and Schaechter, M (2012). *Topics in Ecological and Environmental Microbiology*. 3<sup>rd</sup> Edition, Academia Press.
- Wayne. G. Landis, Ming Ho Yu, 3rd Ed. (2002) *Introduction to Environmental Toxicology*, Lewis Publishers, CRC press, NY.

<b>Outcomes</b>	<p>On successful completion of the course, the students will</p> <ul style="list-style-type: none"> <li>➤ 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.</li> <li>➤ Know the basis of toxicology and an overview about natural and anthropogenic toxicants</li> <li>➤ comprehend the entry, distribution and mode of action of the toxicants in the environment</li> <li>➤ explain the effects of toxicants in various systems like respiratory, excretory, reproductive and cardiovascular.</li> <li>➤ Be trained in the field of toxicity testing methods and assessments of risks caused by toxicants.</li> </ul>
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Semester-II				
Coursecode:	CoreCourse-8	T/P	C	H/W
22MES2C4	Lab-II:EnvironmentalMicrobiology,Biotechnologyand Toxicology	P	4	8
<b>Objectives</b>	<p>➤ The course provides practical guidelines on conducting experiments across the entire spectrum of environmental toxicology, biotechnology and microbiology.</p> <ol style="list-style-type: none"> <li>1. Good Microbiology laboratory practices: Laboratory safety (Do's and Don'ts),</li> <li>2. To prepare basic liquid (Nutrient broth) and basic solid media (Nutrient Agar and Potato Dextrose Agar) for cultivation of bacteria and fungi.</li> <li>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</li> <li>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)</li> <li>5. Enumeration of microbes from soil and air</li> <li>6. Examination of Mycorrhizae – VAM</li> <li>7. Isolation of genomic DNA from bacteria</li> <li>8. Isolation of genomic DNA from plant</li> <li>9. Isolation of genomic DNA from animal tissue</li> <li>10. Survey of degradative plasmids in microbes growing in polluted environment</li> <li>11. Estimation of reducing sugars in toxic waste.</li> <li>12. Estimation of protein from toxic waste.</li> <li>13. Case studies on environmental effects of pesticides.</li> <li>14. Modeling of pollutant dispersion.</li> <li>15. Toxicogenomic and pharmacogenomic evaluation of pollutants.</li> </ol>			
<b>Reference and Textbooks:</b>	<p>Alexander N. Glazer Hiroshi Nikaido (1995) <i>Microbial Biotechnology</i>, WH Freeman and Company, NY, USA.</p> <p>Bernard R. Glick and Jack J. Pasternak (1994) <i>Molecular Biotechnology: Principles and Applications of Recombinant DNA</i>, ASM Press. Washington, DC USA.</p> <p>Brown, T.A. (1995) <i>Gene Cloning - A Introduction</i> - Chapman &amp; Hall, London.</p> <p>David Woolley, Adam Woolley (2013). <i>A Guide to Practical Toxicology: Evaluation, Prediction, and Risk</i>. 2<sup>nd</sup> Edition. Taylor and Francis Publication.</p> <p>Dr. Ratna Trivedi (2016). <i>Practical Manual of Environmental, Microbiology and Biotechnology</i>. Academic Press.</p> <p>Glazer and Nikaido (1995) <i>Microbial Biotechnology</i>. WH Freeman &amp; Co., New York.</p> <p>Jayanta Kumar Patra, Gitishree Das, Swagat Kumar Das, Hrudayanath Thatoi (2020). <i>A Practical Guide to Environmental Biotechnology (Learning Materials in Biosciences)</i>. Springer publication.</p>			
<b>Outcomes</b>	<p>On the successful completion of the course, students will be able to</p> <ul style="list-style-type: none"> <li>➤ Explain the role of microbes in degradation of environmental pollutants</li> <li>➤ Acquire skills in manipulating the microbes for biodegradation of pollutants</li> </ul>			

	<ul style="list-style-type: none"><li>➤ Develop processes for waste bioconversion to value-added products.</li><li>➤ Become an entrepreneur/researcher in the areas of environmental biotechnology.</li></ul>
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Semester-II					
Coursecode: 22MES2E1	DSE-IIA		T/P	C	H/W
	BIOREMEDIATION		T	4	4
<b>Objectives</b>	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.				
<b>Unit-I</b>	Bioremediation - factors affecting bioremediation, types. Organic pollutants - aerobic and anaerobic degradation of organic pollutants - degradation of aliphatic, aromatic, polyaromatic and chlorinated compounds, biotechniques for air pollution abatement and odour control - bioscrubbers, biobeds, biotrickling filters, biodeterioration.				
<b>Unit-II</b>	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, biomining, Nitrate-Nitrification and denitrification - Phosphate - Biological Phosphate removal, Phytoremediation.				
<b>Unit III</b>	Waste utilization and management, Bioplastics, Biosensor technology, Biofuels, Vermitechnology, SCP, Biofertilizer.				
<b>UnitIV</b>	Molecular techniques in bioremediation - pathway construction - Biochemical background, Operon regulation, Vectors, Hybrid pathways and enzymes, Noncatabolic genes for catabolic pathway construction, Rational enzyme redesign.				
<b>UnitV</b>	GEM - degradative plasmids, promoting GEM survival - implications for bioremediation, preventing GEM survival - suicide contaminant systems - GMOs in food production - transgenic crops - Biosafety - Bioethics - Patents - Patent laws and regulation.				
<b>Reference and Textbooks:</b>					
Ronald I. Crawford and Don I. Crawford, 1996, <i>Bioremediation - Principles and Applications</i> , Cambridge University Press.					
Nuzhat Ahmed, Fouad M. Qureshi and Obaid Y. Khan, 2006 <i>Industrial and Environmental Biotechnology</i> - Horizon Press					
Paul A. Rochelle, 2001 <i>Environmental Molecular Biology</i> , Horizon Press.					
<b>Outcomes</b>	On successful completion of the course, Students will <ul style="list-style-type: none"> <li>➤ Understand the nature and importance of bioremediation;</li> <li>➤ Know the influence of site characteristics on bioremediation rates;</li> <li>➤ Have knowledge of the impacts of contaminant characteristics on the bioremediation process</li> <li>➤ Understand the use of bioremediation in real world applications</li> </ul>				

Semester-II					
Coursecode: 22MES2E2	DSE-IIB		T/P	C	H/W
	BIODIVERSITYANDCONSERVATION		T	4	4
<b>Objectives</b>	Biodiversitydescribestheorganismsinthenaturalenvironment,whichprovidetheecosystem services that form our natural capital: fresh water, clean air, soil fertility andbiologicalpestcontrol.Biodiversityisfundamentaltothefuturesustainabilityoftheworld'snaturalresources.Conservationofbiodiversity,oneconomicgroundsalone, needstobecomecorebusinessinthemanagementofournaturalresources.				
<b>Unit-I</b>	<b>Scope and Constraints of Biodiversity Science</b> :Biological Diversity:Species –Originof new species, Description of new species, Community and ecosystem diversity Geneticdiversity- Systematics in Diversity –Environment and Genetic Variations – BiologicalClassification – Phylogenetic Relationship – Ecological Biodiversity –Species Concept –Biological and Phylogenic Concepts; Species Inventory – Biodiversity hot spots IUCNcategories–Reddatabook.CaseStudies–DeciduousForests-DesertLizardcommunities– MarineandCoralReef-FishCommunities-Islandspecies—Western andEasternGhats–Himalayas.				
<b>Unit-II</b>	<b>Species Diversity:</b> Global Distributionof Species- Tropical species diversity –Diversityin terrestrial,marine and freshwater –Micro-organisms-lower and higher plants- lowerandhigherinvertebratesandvertebrates;SpeciesextinctionandEndangeredspecies;Monitoring indicator speciesand habitats;Threats to biodiversity:Extinction –Past rateofExtinction– HumanCausedExtinctions–Endemicspecies-Extinctionrates-Man andanimalconflicts.				
<b>Unit-III</b>	<b>HabitatsandEcosystem:</b> Historyofecosystemecology,HumaninducedEcosystemchange,Urb anEcosystemClassification– Ecosystemmapping,tropicalforests,grasslands,wetlands,coralreefs,mangroves;Habitatloss:Ha bitatdestruction–Fragmentationanddegradation –desertification – Habitatrestoration;InvasiveSpecies:theirintroductionpathways,biologicalimpactsofinvasives peciesonterrestrialandaquaticsystems;ImpactsofExploitationonTargetandNon- targetTerrestrialand AquaticspeciesandEcosystems.				
<b>Unit -IV</b>	<b>ValuesofBiodiversity</b> Instrumental/Utilitarianvalueandtheircategories,Directusevalue;Indire ct/Non- consumptiveusevalue,IntroductiontoEcologicalEconomics;MonetizingthevalueofBiodiversit y;IntrinsicValue;Ethicalandaestheticvalues,Anthropocentrism,Biocentrism,Ecocentrismand Religions;IntellectualValue;EconomicsofEcosystem,GreenRevolution,FoodPlants,medicina andornamental plants,animaluses–livestockandfisheries.				



<b>Unit-V</b>	<b>Conservation and Management</b> National Legislation – Protection of Wild flora and Fauna - Protection of National Habitats - National and International Protected Areas - Current Practices in Conservation - <i>in situ</i> Conservation and <i>ex situ</i> Conservation of Threatened Species – Biodiversity Act 2002 - Forest protection Act - Forest conservation Act 1980 - Multilateral Treaties – Biodiversity Conventions. Environmental ethics – Biodiversity - Socio- Political Perspective; Community conserved Areas (CCAs) - Range and significance of CCAs. Conservation and sustainable development -
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	<p>traditionalsocieties-Governmentactionlocallegislation-nationallaws-NationalBiodiversityActandNationalBiodiversityAuthority.Internationalapproachestoconservationandsustainabledevelopment-Ongoingproblems-possibleresponses-roleofconservationbiologists.</p>
<p><b>ReferenceandTextbooks:</b></p> <p>Chaudhuri,A.B.andD.D.Sarkar(2003),<i>MegadiversityConservation,flora,FaunaandMedicinalPlantsofIndia'shotsspots</i>,DayaPublishingHouse,Delhi.</p> <p>Singh,M.P.,B.S.SinghandSomaS.Dey(2004),<i>ConservationofBiodiversityandNaturalResources</i>.DayaPublishingHouse,Delhi.</p> <p>DadhichL.K.andA.P.Sharma(2002),<i>Biodiversity–StrategiesforConservation</i>,APHPublishingCorporation,NewDelhi.</p> <p>Khan,T.IandDhariNAIAjmi(1999),<i>GlobalBiodiversity–ConservationMeasure</i>,PointerPublishers,Jaipur.</p> <p>Krishnamurthy,K.V(2003),<i>AnAdvancedTextbookonBiodiversity–PrinciplesandPractice</i>,OxfordandIBHPublishing,NewDelhi.</p> <p>T.B.1:Krishnamurthy,KV.,2003,<i>AnadvancedTextbookonbiodiversity</i>,OxfordandIBHBook.Co.,NewDelhi.</p> <p>T.B.2:Hall,BK.andHallgr imsson,B.,2014.<i>Evolution</i>,5thEdition,JohnesandBartlettIndiaPvt.Ltd.NewDelhi.</p> <p>Ridley,M.,2004,<i>Evolution</i>,3rdEdition,BlackwellScienceLtdaBlackwellPublishingcompany,USA.</p>	
<b>Outcomes</b>	<p>Protected and restored marine and estuarine ecosystems. Controlled invasive species,Mitigateddrylandsalinity,Promotedecologicallysustainablegrazing,Minimizedimpacts ofclimatechangeonbiodiversity,Maintainedandrecordindigenouspeoples' Ethnobiologicalknowledge,Improvedscientificknowledgeandaccesstoinformation.</p>

Semester-III				
Coursecode:	CoreCourse-9	T/P	C	H/W
22MES3C1	BIostatistics and Research Methodology	T	4	4
<b>Objectives</b>	To impart understanding on the concepts of biostatistics and to improve the Computing knowledge of the statistical methods related to environment			
<b>Unit-I</b>	<b>Basic statistics:</b> 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 analyzing oceanographic data and filtering of scientific data			
<b>Unit-II</b>	Sampling Methods: Probability sampling, random sampling, systematic sampling, stratified sampling, cluster sampling and multi-stage sampling. Non-probability sampling: convenience sampling, judgement sampling, quota sampling.			
<b>Unit-III</b>	Tests of Significance – Null and alternative hypothesis – error level of significance – Equal and Unequal Sampling - t, z, $\chi^2$ 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.			
<b>Unit-IV</b>	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.			
<b>Unit-V</b>	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.			
<b>Reference and Textbooks:</b>				
Arvind Shende and Vijay Upagade (2010). <i>Research Methodology</i> . S. Chand Publications.				
Bliss, G.I. (1970), <i>Statistics in Biology</i> . McGraw Hill Book Company, Vol. I and II. New Delhi.				
Byron S Gottfried (1996), <i>Programming with C</i> , Hill Publishing Co, New Delhi. Gupta S.P. (2014). <i>Statistical Methods</i> . Sultan Chand & Sons Publications.				
Gupta, S.P. (1996) <i>Statistical Methods</i> , Sultan Chand & Sons Publications, New Delhi. Haynes, R (1982) <i>Environmental Science Methods</i> , Chapman & Hall, London.				
Khan, I.A and Kanum, A., (1994) <i>Fundamentals of Bio-Statistics</i> , Ukaaz Publication, Hyderabad.				

<p>Kothari, C.R. (1996), <i>Quantitative Techniques</i>, Vikas Publishing House Pvt Ltd, Hyderabad.</p> <p>Kothari, C.R., (1989), <i>Research Methodology – Methods and Techniques</i>. Wiley Eastern, New Delhi.</p> <p>Miller, J., (1989), <i>Statistics for Advanced Level</i>, Cambridge University Press.</p> <p>Rastogi V.B (2009). <i>Fundamentals of Statistics</i>. ANE Books.</p> <p>Snedcor, G.W. and Cochran, W.G. (1982), <i>Statistical Methods</i>, Academic Press.</p> <p>Vittal, R. (1986) <i>Business Mathematics and Statistics</i>, Murgham Publications.</p> <p>Wardlaw, A.C. (1985), <i>Practical Statistics for Experimental Biologists</i>. Wiley Chichester.</p> <p>Sharma, B.A.V., Ravindra Prasad, D. and Satyanarayana, P (1989) <i>Research Methods in Social Sciences</i>. Sterling Publishers Pvt. Ltd.</p> <p>Wayne W. Daniel, Chad L. Cross (2014). <i>Biostatistics: Basic Concepts and Methodology for the Health Sciences</i>. 10<sup>th</sup> Edition. Wiley Publication.</p>	
<b>Outcomes</b>	<p>On successful completion of the course, the students</p> <ul style="list-style-type: none"> <li>➤ Know the types of research and scientific databases, report writing and plagiarism.</li> <li>➤ Choose the research that they want to carry out.</li> <li>➤ Identify and design their research problems.</li> <li>➤ Understand the principles of research methods and instruments required for their research experiments.</li> <li>➤ Apply their knowledge on instrumentation for environmental analysis, and field works and data collection.</li> </ul>

<b>Semester-III</b>				
<b>Coursecode:</b>	<b>CoreCourse-10</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
22MES3C2	<b>RemoteSensing&amp;GIS</b>	<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	ToteachtheprinciplesandapplicationsofspatialinformationtechnologiesvizRS,GPSandGISaboutthedistributionofresources.Togivehands-ontrainingontheusesofGISsoftwareinenvironmentalstudies.			
<b>Unit-I</b>	Elements of photographic systems and computer applications. Land sat. IRS and othersatellite systems- satellite data. Principles involved in thermal IR image and microwaveimageinterpretation.ApplicationsofdifferenttypesofimagesinearthSciences,EnvironmentalSciences,Archeology,Marinestudies,Forestry,Soils,Hazard managementetc.			
<b>Unit-II</b>	Conceptsandfoundationsofremotesensing-Historyofremotesensing-Electro-magneticenergy-Propertiesandinteractionwiththeearth.Atmosphericwindows.Black,whiteandgreybodies,sourcesofEMR.Imageinterpretations.Aerialphoto-classificationbasedonattitudeofcameralens,distortionscausedduetooflightirregularities,overlaps,s, scale, reliefdisplacementanditseffects.Photorecognition elements.Differenttypesofphotographs			
<b>Unit-III</b>	Introductionto GeographicalInformation SystemsandGISsoftware,FundamentalsofGIS Layers and features, Raster/Vector- Georeferencing and projection, Spatial data andGISbasics;Dataattributesandspatialtopology,Projection/Imageregistration, Digitizationanddataattributes-mapdatarepresentation,GPS.			
<b>Unit-IV</b>	GIS Applications: Resources mapping, Inventory and monitoring natural resources, Landcover mapping, Wetland mapping – Applications to Agriculture -Water Management,SpecificApplications-Infrastructure-GroundWater.GPSApplications-Principlesof Accuracy-DatabaseCreation-NetworkingofData.			
<b>Unit-V</b>	Remotesensingapplications-ImpactAssessment-PollutionMonitoring-Water-Air -Ocean Pollution – Land Degradation – Desertification – Industry – Mining – GroundWaterModeling-DamageAssessment-CoastalandMarineapplications-FutureSensors-SatelliteSystem-ENVISAT-MeghaTropiques-TRMM-EOSMissions-IntegralEarthObservationStudies-GlobalChange-Casestudies.			

**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.

Kramer J. Herbert (2002), *Observation of Earth and its Environment – Survey of Missions and Sensors* Springer-

Verlag. *Fundamentals of Remote Sensing*, George Joseph (2003),

<p>Universities Press (India) Ltd., Hyderguda, Hyderabad</p> <p>Martin Wegmann, Benjamin Leutner and Stefan Dech (2016). <i>Remote Sensing and GIS for Ecologists: Using Open Source Software (Data in the Wild)</i>. Pelagic Publication.</p> <p>Muralikrishna, I. V. (1995). <i>Remote Sensing and GIS for Environmental Planning</i>, Tata-McGraw Hill.</p> <p>Roody, G. M. and Curran, P. J. (1994). <i>Environmental Remote Sensing from Regional and Global Scales</i>, Singh, R. B. (1992), <i>Environmental Monitoring: Applications of Remote Sensing and GIS</i>, Geocartha International Centre, Hong Kong.</p> <p>William K Pratt (2001), <i>Digital Image Processing</i>, John Wiley &amp; Sons.</p>	
<b>Outcomes</b>	<p>On successful completion of the course, students can</p> <ul style="list-style-type: none"> <li>➤ recognize that Remote Sensing and Geographic Information System (RS-GIS) can be a powerful tool for geospatial analysis.</li> <li>➤ Acquire adequate knowledge on principles and basic concepts of environmental geoinformatics</li> <li>➤ Understand the basic concepts of GIS and its mechanisms</li> <li>➤ Know the various types of GPS systems</li> <li>➤ Learn to interpret satellite images</li> <li>➤ Understand Image Classification Techniques, Image enhancement and interpretation methods</li> <li>➤ Use GPS for various environmental applications.</li> <li>➤ Able to apply the tools of remote sensing and GIS for environmental disaster management and conservation</li> </ul>

Semester-III				
Coursecode:	CoreCourse-11	T/P	C	H/W
22MES3C3	<b>ENVIRONMENTALIMPACTASSESSMENT</b>	T	4	4
<b>Objectives</b>	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.			
<b>Unit-I</b>	<b>Fundamental of EIA:</b> Definition and Evaluation of EIA in India – Types of Impact- Characteristics - Steps of EIA- Sustainable Development- 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.			
<b>Unit-II</b>	<b>EIA Methodologies:</b> Checklist Methodologies - Adhoc Method - Network Methods - Matrix Methods - Map Overlay Method - Preparing EIA - Interacting Parameters Interaction - Environment and Development Activities - Comparative Studies on Methodology. Prediction and Assessment of Impacts on Biological, Surface Waters, Ground Water, Air, Noise, Radiation Hazards.			
<b>Unit III</b>	<b>Environmental Laws and Acts:</b> Environmental Policies - National and International Trends, Changes in Global Perspective, International Treaties. National Policies: National Environmental Policy, National Forest Policy, National Water Policy, Rehabilitation and Resettlement Policy; Evolution of Environmental Legislation in India, Legal Provisions for Environmental Protection; Various Acts, Rules and Regulations. Notifications Issued under Various Acts and Rules. Environmental Standards, Criteria for Standards Setting. Public Liability Insurance Act and Legal Aspects Relating to Hazardous and Toxic Substances. Role of National Green Tribunal.			
<b>Unit IV</b>	<b>Environmental Ethics:</b> Implementation of International Emission Trading, Resource Consumption Patterns and the need for Equitable Utilization - Equity - Disparity in the Northern and Southern Countries, Urban and Rural Equity Issues - The need for General Equity, Preserving Resources for Future Generation - The Rights of Animals - Preparation of Environmental Management Plan and Criteria for Selection of Environmental Factors, Alternatives Policies of World Summit 1972, RIO Conference Agenda 21, Montreal Protocol, Kyoto Protocol, Climate Change Mitigation.			
<b>Unit V</b>	<b>Case Studies:</b> 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.			



**ReferenceandTextbooks:**

BregmanJ.I(1999),EnvironmentalImpactStatements,LewisPublishers,London.

CharlesH.Eccleston(2011).*EnvironmentalImpactAssessment:AGuidetoBestProfessionalPractices*.  
CRCPress.

EcclestonC.H,(2000),EffectiveEnvironmentalAssessment,LewisPublishers,London.

<p>EranchBharucha,(2005),TextbookofEnvironmentalStudies,UniversityGrantsCommission</p> <p>JaneHolderandMariaLee,(2007),EnvironmentalProduction,LawandPolicies,SecondEdiction.</p> <p>JohnGlasson(2005),IntroductiontoEnvironmentalImpactAssessment,NaturalandBuiltEnvironment Series.Routledge,TaylorandFrancis.</p> <p>Khandeshwar S.R, Raman N.S,Gajbhiye A.R(2019). <i>Environmental Impact Assessment</i>. DreamtechPress.</p> <p>LarryW.Canter(2013),EnvironmentalImpactAssessment,JohnWileyandSons.RamachandranS(2019).<i>EnvironmentalImpactAssessment</i>.AirwalkPublications.</p> <p>SingletonR,CastlePandSortD(1999),EnvironmentalAssessment,ThomasTelfordPublishingLondon.</p> <p>SureshK.Dhameja,(2005),EnvironmentalScienceandEngineering,PublishedbySanjeevKumarKataria,Delhi.</p>	
<b>Outcomes</b>	<p>Onsuccessfulcompletionofthecourse,studentscan</p> <ul style="list-style-type: none"> <li>➤ UnderstandthescopeofEIA</li> <li>➤ LearnttypesandmethodsofEIAProcess</li> <li>➤ Developedfactorscorrelationskills</li> <li>➤ IdentifytheroleofEIAinsustainableenvironmentmanagement</li> <li>➤ ImprovedtheknowledgeaboutEIA significanceandmagnitude</li> <li>➤ Involvedeconometricvaluesonlevelofimpact</li> <li>➤ Developedinteractionmatrixbetweenvariables</li> <li>➤ LearntnationalandinternationalprotocolsonEI</li> </ul>

<b>Semester-III</b>				
<b>Coursecode:</b> 22MES3C4	<b>CoreCourse-11</b>	<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>Lab-III:Biostatistics&amp;Researchmethodology,Remote Sensing&amp;GISandEIA</b>	<b>T</b>	<b>4</b>	<b>8</b>
<b>Objectives</b>				
<p>➤ 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.</p>				
<ol style="list-style-type: none"> <li>1. Calculation of mean, median and mode,</li> <li>2. Calculation of standard deviation.</li> <li>3. Statistical Data Analysis – Mean, Standard Deviation, Standard Error</li> <li>4. Statistical Data- Analysis of Variance (ANOVA)</li> <li>5. Preparation of simple Vector map, Toposheet reading and GPS field survey.</li> <li>6. Visual Interpretation of Geomorphic features from the Satellite image and Aerial photographs</li> <li>7. Toposheet and Satellite Imagery Acquisition</li> <li>8. Georeferencing of toposheet/Satellite Imagery</li> <li>9. Creation of Vector Layers</li> <li>10. Raster Image Processing</li> <li>11. Image Classification Techniques</li> <li>12. Study Map Representation/Creation</li> <li>13. Case studies on effective utilization of environmental laws: oil refineries, petrochemical industry</li> <li>14. Comparative analysis of various megabuilding projects and its impact assessment.</li> <li>15. Impact assessment of green belts.</li> <li>16. Visits- sanctuaries, reserves</li> <li>17. Pollution Control Board Visits and Reports</li> </ol>				
<b>Reference and Textbooks:</b>				
<p>Arvind Shende and Vijay Upagade (2010). <i>Research Methodology</i>. S. Chand Publications.</p> <p>Charles H. Eccleston (2011). <i>Environmental Impact Assessment: A Guide to Best Professional Practices</i>. CRC Press.</p> <p>Gupta S.P. (2014). <i>Statistical Methods</i>. Sultan Chand &amp; Sons Publications.</p> <p>Martin Wegmann, Benjamin Leutner and Stefan Dech (2016). <i>Remote Sensing and GIS for Ecologists: Using Open Source Software (Data in the Wild)</i>. Pelagic Publication.</p>				
<b>Outcomes</b>				
<p>➤ 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 skills in this new and upcoming technology.</p>				

<b>Semester-III</b>					
Coursecode: 22MES3E1	<b>DSE-III A</b>		<b>T/P</b>	<b>C</b>	<b>H/W</b>
	<b>Instrumentation &amp; Analytical Techniques</b>		<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	<p>➤ The purpose of this course is to introduce knowledge and skills in analysis of environmental pollutants in environmental matrices, including extraction, sample preparation and instrumentation analysis, theory and techniques in quantitative and qualitative methods.</p>				
<b>Unit-I</b>	<p>Principles and application of Spectrophotometry-UV-Visible spectrophotometry, Spectrofluorimetry, Titrimetry, Gravimetry, Colourimetry, Infrared spectrophotometry, NMR, ESR, Microscopy-phase, light and fluorescence microscopes, Scanning and Transmission electron microscopes.</p>				
<b>Unit-II</b>	<p>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 biophysical method used for analysis of biopolymer structure, Hydrodynamic methods, Plasma emission spectroscopy.</p>				
<b>Unit-III</b>	<p>Electrophoresis, SDS-PAGE, Agarose gel electrophoresis, solid and liquid scintillation, autoradiography, X-ray fluorescence, Flame photometry, Gas-liquid chromatography, High pressure liquid chromatography, Ultracentrifugation</p>				
<b>Unit -IV</b>	<p>Conductometry, voltammetry, turbidimetry, pH meter, meteorological monitoring devices, portable gas analyser, calorimeter, Neutron activation analysis.</p>				
<b>Unit-V</b>	<p>Methods for measuring nucleic acid and protein interactions, DNA fingerprinting, Molecular markers RFLP, AFLP, RAPD, Sequencing of proteins and nucleic acids, southern, northern, western blotting techniques, PCR-polymerase chain reaction.</p>				
<b>Reference and Textbooks:</b>					
<p>Uppadahay, A., Uppadahay, N. and Nath, N. (2016), Biophysical Chemistry, Principles and Techniques, Himalaya Pub. House, New Delhi.</p> <p>Sawyer, C.N., McCarty, P.L. and Parkin, G.F. (2002), Chemistry for Environmental Engineering and Science, McGraw-Hill Education</p> <p>Rupa, H.H. and Krist, H. (1998), Laboratory Manual for the Examination of Water, Wastewater and soil, VC H Publication, New York.</p> <p>Sharma, B.K. (2001), Instrumental Methods of Chemical Analysis, Goel Publishing House, Meerut, India</p>					

<b>Outcomes</b>	The student on exposure to this course will be able to <ul style="list-style-type: none"><li>➤ Understand the basics and requirement of environmental analysis</li><li>➤ Understand the environmental quality parameters to be monitored and determined</li><li>➤ Know the role of sample preparation in environmental analysis</li><li>➤ Understand the instrumental techniques and methods of analysis</li></ul>
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Semester-III					
Coursecode: 22MES3E2	DSE-IIIB		T/P	C	H/W
	ENVIRONMENTALEUCATION		T	4	4
<b>Objectives</b>	<p>➤ 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.</p>				
<b>Unit-I</b>	<p><b>Definition, concept, policy, history and practices:</b> What is environmental education- Major requirements of environmental education- Interdisciplinary, Psychological, cultural and physical- Interrelatedness- 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 ethics and Bioethics in mangrove environment- Endangered species- Animal cruelty.</p>				
<b>Unit-II</b>	<p><b>Role of institution:</b> Teachers preparation and curriculum development for environmental Education- Environmental education school level, Universities, R&amp;D Institutions- Education for physical planners- Environmental management education - 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.</p>				
<b>Unit- III</b>	<p><b>Community and environmental education.</b> 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 effort environmental prospective- International co-operation- Support Policies and systems.</p>				
<b>Unit -IV</b>	<p><b>Mass media in environmental and eco-tourism:</b> Radio- Television- Newspapers- Cinema- Poster and Banners- Mass 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.</p>				

<b>Unit-V</b>	<b>Sustainable Development and Environmental Awareness</b> -Learning to live in harmony with nature - environmental education for development, conservation of soil, water, forests, wildlife, energy resources, movement to save environment, eco-friendly technology-Alternate sources of energy-Waste management-Population and
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	environment.
<b>Reference and Textbooks:</b>	
<p>Canter, E. W. (1977): <i>Environmental Impact Assessment</i>. McGraw Hill Co., New York</p> <p>Fedron, E. (1980): <i>Man and Nature</i>, Progress Publishers, Moscow</p> <p>Kormondy, E. (1991): <i>Concept of Ecology</i>, Prentice Hall of India, New Delhi.</p> <p>Odem, E. P. (1975): <i>Ecology</i>, Oxford and IBH Publishing Co., New Delhi.</p> <p>Purdom, P. W. &amp; Anderson: <i>Environmental Science</i>, Charles E. Merrill Publishing Co.,</p> <p>Saxena, A. B. (1996): <i>Education for the Environmental Concerns, Implications and Practices</i>, Radha Publication, New Delhi.</p> <p>Sharma, P. D. (1993): <i>Environmental Biology</i>, Rastogi &amp; Co., Meerut.</p>	
<b>Outcomes</b>	<p>On successful completion of the course, the students get</p> <ul style="list-style-type: none"> <li>➤ Knowledge in the concepts and scope, basic requirements for healthy environment, environmental quality, human exposure and health impact.</li> <li>➤ Knowledge of the Industrial pollution and chemical safety in public exposure from industrial sources, Hazards by industry major chemical contaminants at workplace. Industrial environmental accidents.</li> <li>➤ Knowledge about Environmental Disease present study in Fluorosis and Allergies; Epidemiological issues.</li> <li>➤ Knowledge of understand course will equip student with basic knowledge on safety issues related with explosion, pollutant release in water and air, and to implement measures during outbreak of flue epidemic at workplace.</li> </ul>



Semester-IV						
Coursecode: 22MES4C1	CoreCourse-13			T/P	C	H/W
	OCCUPATIONALHEALTHHAZARDS ANDINDUSTRIALSAFETY			T	4	4
<b>Objectives</b>	The students on exposure to this course will understand the different types of hazards and disasters possible in the industries. Focus has been made on the safety and management practices in industries by highlighting certain case studies.					
<b>Unit-I</b>	<b>Health Hazards:</b> 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 Ergonomical Hazards – Classification of Biohazardous Agents – Bacterial, Rickettsial, Chlamydial, Viral Fungal and Parasitic.					
<b>Unit-II</b>	<b>Health Disorders:</b> 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 <sub>2</sub> S) – Their Effects and Prevention.					
<b>Unit III</b>	<b>Industrial Safety Measures:</b> First Aid – Principles, Rules and Training, Personal Protective Equipments (PPE) – Respiratory and Non Respiratory Devices, Maintenance of Machines and Equipments, Fire Extinguishers – Types and Handling, Fire Detection and Alarm Systems, Water Spray Systems for Explosions.					
<b>Unit IV</b>	<b>Plans, Policies and Rules Related to Industrial Safety:</b> Threshold Limit Values (TLV), The Factories Act, 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 Act 2003, Indian Explosive Act – 1984. Hazardous Materials Transportation Rules.					
<b>Unit V</b>	<b>Case Studies:</b> 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 – <u>Spyros Disaster</u> 1978, Oppau Explosion, Germany 1921, Courrieres Mine Disaster, France 1906, Chernobyl Disaster, Ukraine 1986, Halifax Explosion, Canada 1917, Benxihu Colliery Explosion 1942.					

**Reference and Textbooks:**

Della D. E., and Giustina, (1996), Safety and Environmental Management, Van Nostrand Reinhold International Thomson Publishing Inc.

Goetsch D. 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, Pitman Publishing United Kingdom.

<b>Outcomes</b>	<p>On completion of the course, students</p> <ul style="list-style-type: none"> <li>➤ Apply knowledge of science in the management of industrial safety and health.</li> <li>➤ Identify industrial safety and health problems.</li> <li>➤ Understand professional and ethical responsibility in safety management of industries.</li> <li>➤ Learning to deal with the contemporary issues surrounding occupational safety and health.</li> <li>➤ Learning techniques and control of hazardous substances.</li> <li>➤ Recognize the need for professional development in this field.</li> <li>➤ Solve the problems related with industrial safety.</li> <li>➤ Understand the impact of occupational safety and health</li> </ul>
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Semester-IV					
Coursecode: 22MES4C2	CoreCourse-14		T/P	C	H/W
	CLIMATECHANGE		T	4	4
<b>Objectives</b>	➤ To impart the knowledge of fundamental scientific principles, concepts and global perspective underlying climatic change.				
<b>Unit-I</b>	Climate change – concept of climate change – Atmosphere-atmospheric motion, Earth's rotation: Coriolis effect, global atmospheric circulation. Human Impact on climate- greenhouse gas emissions, Fossil fuel emission scenarios, IPCC. Greenhouse 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.				
<b>Unit-II</b>	Adaptation and Mitigation Responses and policies of climatic changes - Emission trading/carbon credits schemes. 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				
<b>Unit III</b>	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 working group II working group III.				
<b>Unit IV</b>	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 negotiation evolved over the past years and highlights of some key issues relevant to future climate change regime.				
<b>Unit V</b>	Climatic change and Socio-economic implications: Economic importance - drought and desertification- fishing and forestry- changes in monsoon pattern- industries- food production- health care- tourism- transportation and energy consideration. Carbon tax and emission trading, Green fiscal policy				
<b>Reference and Textbooks:</b>					
Botkin, D.B. and Keller, E.A. (2007), <i>Environmental Science: Earth as a Living Planet</i> , 6th edition, John Wiley & Sons, USA.					
Botkin, D.B. and Keller, E. A. (2014). <i>Environmental Science: Earth as a Living Planet</i> . 9 <sup>th</sup> Edition. John Wiley & Sons.					
Burroughs, W.J. (2007). <i>Climate Change: A Multidisciplinary Approach</i> . 2 <sup>nd</sup> Edition. Cambridge University Press.					
Chasek, P.S. (2004), <i>The Global Environment in the Twenty-First Century- Prospects for International Co-operation</i> , Manas Publications, New Delhi.					

<p>Climate Change: Science, Strategies and Solutions, Claussen, E. (2001), Arlington VA.</p> <p>Climate Change: A Multidisciplinary Approach, 2nd edition, Cambridge University Press. Dash, S. K. (2007), <i>Climate Change-An Indian Perspective</i>, Cambridge University Press India Pvt Ltd., New Delhi.</p> <p>Dodds, F. and Middleton, T. (2002), <i>Earth Summit, a New Deal</i>, Earthscan Publications Ltd., UK.</p> <p>Enger, E. D. and Smith, B. F. (2006), <i>Environmental Science: A Study of Interrelationships</i>. 11th edition, McGraw Hill Inc., USA.</p> <p>Hardy, John, T. (2003), <i>Climate Change: Causes, Effects, Solutions</i> Wiley and Sons, USA.</p> <p>Ranade, P. S. (2008), <i>Climate Change and Biodiversity: Perspectives and Mitigation Strategies</i> ICFAI University press.</p> <p>Ranade, P. S. (2008). <i>Climate Change and Biodiversity: Perspectives and Mitigation Strategies</i>. ICFAI University press.</p>	
<b>Outcomes</b>	<p>On completion of the course, students will be able</p> <ul style="list-style-type: none"> <li>➤ to understand the environmental issues, energy systems, management related to climatic change</li> <li>➤ obtain in depth knowledge of effect of climatic change on global society</li> <li>➤ know the way in which society works with the effects of climate change and climate adaptation.</li> </ul>

Semester-IV					
Core		Core Course-15	T/P	C	H/W
<b>Coursecode:</b>		<b>NATURALRESOURCEMANAGEMENT</b>	<b>T</b>	<b>4</b>	<b>4</b>
<b>Objectives</b>	➤ The course deals with Waste treatment technologies for resource and energy recovery to deliver value-added products.				
<b>Unit-I</b>	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.				
<b>Unit-II</b>	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.				
<b>Unit-III</b>	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 based energy, Dendrothermal energy, Energy from urban waste, Bagasse based energy.				
<b>Unit-IV</b>	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.				
<b>Unit-V</b>	Water-Surface and groundwater, Water management, Rain water 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 – a self-employment avenue (small scale industry), Govt. schemes, Training and incentives.				

**Reference and Textbooks:**

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Dasmann, R. F. (1976), *Environmental Conservation*, John Willey and Sons, New

York. Wasi Ullah, Gupta, S. K. and Dalal, S. S. (1972), *Hydrological Measurements for Watershed*

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Murty, J. V. S. (2017), *Watershed Management*, New Age International Publishers

<p>Todd, T.K. and Mays, L.W. (2011), <i>Groundwater Hydrology</i>, Wiley.</p> <p>Agarwal, V.C. (2012), <i>Groundwater Hydrology</i>, PHI Learning.</p> <p>Klee, G.A. (1991), <i>Conservation of natural resources</i>, Prentice Hall Publ. Co., New Jersey.</p> <p>Owen, O.S., Chiras, D.D. and Reganold, J.P. (1998), <i>Natural resource conservation management for a sustainable future</i>, Prentice Hall.</p>	
<b>Outcomes</b>	<ul style="list-style-type: none"> <li>➤ 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.</li> </ul>

