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| M.Sc., ENVIRONMENTAL SCIENCE |
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| **SYLLABUS** |
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| **FROM THE ACADEMIC YEAR**  **2023 - 2024** |
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| **TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005** |
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| **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. |

**Template for P.G., Programmes**

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| **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 | - |  |  |  |
|  | **20** | **30** |  | **22** | **30** |  | **26** | **30** |  | **23** | **30** |
| **Total Credit Points -91** | | | | | | | | | | | |

**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**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – I | 5 | 7 |
| Core – II | 5 | 7 |
| Core – III | 4 | 6 |
| Elective – I | 3 | 5 |
| Elective – II | 3 | 5 |
|  |  | **20** | **30** |

**Semester-II**

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| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | 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 |
|  |  | **22** | **30** |

**Second Year – Semester – III**

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| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | 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 | - |
|  |  | **26** | **30** |

**Semester-IV**

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| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | 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 | - |
|  |  | **23** | **30** |

**Total 91 Credits for PG Courses**

**M.Sc., ENVIRONMENTAL SCIENCE**

**Programme Structure**

|  |  |  |  |  |  |  |  |  |  |
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| **S.No** |  | **Courses** | **Title of thePaper** | **T/P** | **Credits** | **Hours/**  **Week** | **Marks** | | |
| **I-Semester** | | | | | | | **I** | **E** | **Total** |
| 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:EcologicalMethods,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 |
|  | | | | | **20** | **30** |  |  |  |
| **II-Semester** | | | | | | | | | |
| 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 |  | NME | Non-MajorElective | T | 2 | 4 | 25 | 75 | 100 |
|  | | | | | **22** | **30** |  |  |  |
| **III-Semester** | | | | | | | | | |
| 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 |  | NME | Non-Major Elective | T | 2 | 3 | 25 | 75 | 100 |
|  |  | Internship / Industry Activity | |  | 2 | - |  |  |  |
|  | | | | | **26** | **30** |  |  |  |

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| **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 |
|  |  |  | Skill Enhancement Course – III / Professional Competency Skill |  | 2 | 4 |  |  |  |
|  |  | Extension Activity | |  |  | 1 | - |  |  |
| **Total** | | | | | **23** | **30** |  |  |  |
| **91** |  |  |  |  |

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| **Semester-I** | | | | | | |
| **Coursecode:**  22MES1C1 | | | **CoreCourse-1** | **T/P** | **C** | **H/W** |
| **PrinciplesofEcology** | **T** | **4** | **5** |
| **Objectives** | * Thiscourseistomakethestudentstounderstandthebasicinformationabouttheearth   andenvironment.Theywillalsolearnabouttheinteractionsbetweenthecomponentsofourenvironment,ecologyandalsoaboutenvironmentalissuesanditssustainability. | | | | | |
| **Unit-I** | Definition,principlesandscopeofecology,humanecologyandhumansettlements,  evolution,originoflifeandspecification,Ecosystemstability-cybernaticsandecosystemregulation,ConceptofEcosphereandBiosphere,evolutionofbiosphere. | | | | | |
| **Unit-II** | BiomesandHabitat,Classificationofbiomes–Tundra,Taiga,Grassland,Desert,Evergreen and deciduous forests, Tropical rain forests and their characteristics, flora andfauna;Classification of AquaticHabitats –Freshwaterpond,Wetlands,Beels,Rivers–theircharacteristics,floraandfauna;MarineHabitats–Pelagic,Benthic,Inter-tidal  Estuarine;Mangroves–theircharacteristics,floraandfauna. | | | | | |
| **Unit- III** | Ecosystem structure and functions, abiotic and biotic component, Energy flow, food chain,foodweb,EcologicalPyramids-types,biogeochemicalcycles,CommunityEcology**:**Definitionandconceptofcommunity,communitydiversity,structure,dominance,stratificationandperiodicity.Ecadsandecotypes,EdgeeffectandEcologicalNiche,ecologicalsuccession-characteristics,typesofsuccession,conceptofclimax,  significanceofsuccession. | | | | | |
| **Unit-IV** | Populationecology-density,natality,mortality,survivorshipcurves,agedistribution,growth curves and models, r & k selection, population interactions- Neutralism, symbiosis,commensalism,Mutualism,antagonism,antibiosis,Parasitism,Predator-Preyrelations,  Competition–intra-specificandinter-specific,SystemTheoryandEcologicalModel. | | | | | |
| **Unit-V** | Environmental Microbiology**-**concept and definitions; microbes inagriculture-soilmicroorganismandtheirfunctions,biologicalnitrogenfixation,bio-fertilizers,mycorrhiza;  coastalmanagement,criteriaemployedfordisposalofpollutantsinmarineecosystem,coastalwatersystemandman-madereservoirs,biologyandecologyofreservoirs. | | | | | |
| **ReferenceandTextbooks**:  EugeneP.Odum(2017).*Ecology*.OxfordandIBHPublishingCo.Pvt.Ltd.  ManuelMolles(2015).*Ecology:ConceptsandApplications*.7thEdition.McGraw-HillEducation.  PratibhaSingh,AnoopSingh&PiyushMalaviya(2009)TextBookofEnvironment&Ecology–ExcelPublishers.  RanaS.V.S.(2009)*EssentialsofEcologyandEnvironmentalScience*.PrenticeHallPublishersLtd.  SharmaP.D.(2012).*EcologyandEnvironment*.RastogiPublications | | | | | | |
| **Outcomes** | | Uponsuccessfulcompletionofthecourse,thestudentcan   * Understandtheprinciples,scopeandcomponentsoftheearthandenvironment * Knowthebasicconceptsofecologyandecosystems,factorsanditsinteractionalongwithitssuccessionprocesses * Understandstheconceptofbiodiversity,itstypes,valuesanditsconservationmethods * Learnsaboutvariousenvironmentalissuesandenvironmentalsustainability. * Applytheknowledgeofbasicecologyinfieldstudies. * Understandstheinterrelationbetweentheearthenvironmentandman | | | | |

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| **Semester-I** | | | | | |
| **Coursecode:**  22MES1C2 | | **CoreCourse-2** | **T/P** | **C** | **H/W** |
| **EnvironmentalPollution** | **T** | **4** | **5** |
| **Objectives** | * Togetdeeperinsightsintofundamentalsofwater,airandsoilpollution,monitoringandanalysisofenvironmentalpollution * Torealize,monitorandanalysetheimpactsofpollution,environmentalproblemsanditscontrolmeasures. | | | | |
| **Unit-I** | Concepts of atmosphere and Air Pollutants (Sources and classifications- indoor, vehicular,industrial and othe sources).Meterological aspects of Plume and stack dispersion, Chemicalreactionsofairpollution(Formationoffogandsmog,acidrain).Ozonedepletion–Montreal protocol; Global warming –Kyoto protocol. Air quality standards, Monitoring ofair pollution (Ambient air quality monitoring, Stack monitoring; PM 10 and PM 2.5)–Cleaner technologies (Settling chamber,Cyclones,Fabricfilter, Electrostatic precipitator,Wetscrubber,Controlofgaseouspollutantsabsorption,adsorptionandcombustion  recoverysystem)–onlinemonitoringofpollution. | | | | |
| **Unit-II** | Properties of water; physiochemical and bacteriological properties of water, drinking waterquality standards; Water pollution- Classification (ground water, river, Marine) ources andsinks,Eutrophication.Controlmeasuresofwater pollution(adsorption,flocculation,ionexchange and reverse osmosis). Preventive measures in industries to avoid water pollutions(Endofpipetreatmentsanditsalternatives,onlinemonitoringandtreatmentofindustrial  effluents). | | | | |
| **Unit- III** | Soilpollution;Definition;broadclassification,Sourcesandbroadclassificationofpollution(*e.g.*urbanareas,industrialareas,agricultureandlivestock,landfills,sewagesludge,municipal solid wastedumps andhazardous waste),Soilquality and their impactsonphysio-chemicalandbiologicalpropertiesofsoilandplants,SedimentPollution–Black carbon – Soil pollution control measures – On site (in situ) chemical, physical, soilvapourextraction,soilwashingsolidification/stabilization,electro-kineticremediationthermical and biological methods. Off site (ex-situ, on-site and off-site): chemical methods,Physicalsolidification/stabilization/immobilization,thermal,andbiological(bioremediationandphytoremediation),Biostimulation,Bioaugmentation,Isolation  containmentoftheaffectedarea. | | | | |
| **Unit -IV** | ConceptsandtypesofmunicipalandHazardousSolidWastes(HospitalWastes,Radioactive Wastes,industrial),Transport and waste minimization techniques(Disposal,leachate andlandfillgas managementNuclear reactorsafety).Legislationonmanagementand handling of municipal solid wastes and hazardous wastes Light pollution and controlmeasures;andThermalpollutionandcontrolmeasures.Noisepollution–Sensing,  Measurement,Abatementmeasures. | | | | |
| **Unit-V** | EvaluationofIndustrialDisastersandPollution–Casestudies-ChemicalIndustries–PesticideIndustries,BhopalDisaster,Chernobylaccident,LovecanalDisaster,OilDisasters–Exxon,BritishPetroleum-GulfofMexico;e-wastes,ImpactandRemedial  Measures. | | | | |
| **ReferenceandTextbooks**:  AhluwaliaV.K (2014).*EnvironmentalPollutionandHealth*.TheEnergyandResourcesInstitute,TERI  AvinashChauhan(2020)*EnvironmentalPollutionandManagement*.IKInternationalPublishersLtd  GuptaO.P(2019).*ElementsofEnvironmentalPollutionControl*.KhannaPublication. | | | | | |

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| MarkBrusseau,IanPepper,CharlesGerba(2019)*EnvironmentalandPollutionScience*,3rdEdition,AcademicPress  Rao.C.S.(2018).*EnvironmentalPollutionControlEngineering*.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. * Studentswillbeabletogaindetailedknowledgeonlocalandglobalenvironmentalissuesandanalyzechemicalprocessesinvolvedindifferentenvironmentalproblems. |

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| **Semester-I** | | | | | |
| **Coursecode:**  22MES1C3 | | **CoreCourse-3** | **T/P** | **C** | **H/W** |
| **EnvironmentalChemistry** | **T** | **4** | **5** |
| **Objectives** | * Thecourseintroducestheconceptand scope of environmental chemistry includingsoilchemistry,chemicalcompositionofairandwatertreatmenttechnologies. * Thecoursealsodevelop anunderstanding ofbasicsofchemistry inrelevancetoenvironment and such as,solutions preparation,chemical reactions and their effectsontheenvironment,toprovidestudentswithanunderstandingofthefundamental   chemicalprocessesoccurredonenvironment. | | | | |
| **Unit-I** | ConceptandscopeofEnvironmentalChemistry;acidbasereactions,Stochiometry,Gibb’senergy,Chemicalpotential,Chemicalequilibria,acid-base.reactions.Solubilityproduct,solubilityofgasesinwater,thecarbonatesystem,unsaturatedandsaturated  hydrocarbons,Radionuclides. | | | | |
| **Unit-II** | Classificationofelements,chemicalspeciation,Particles,ionsandradicalsinthe  atmosphere.Chemicalprocessesforformationofinorganicandorganicparticulatematter.Thermochemicalandphotochemicalreactionsintheatmosphere. | | | | |
| **Unit- III** | Firstlawofthermodynamics,enthalphy,adiabatictransformations,secondlawofthermodynamics, Carnot’s cycle, entropy, Gibb’s free energy, chemical potential, phaseequilibria,Gibb’sDonnanequilibrium,thirdlawofthermodynamics,enzymescatalysis,  Michaelis/Mentenequation. | | | | |
| **Unit -IV** | 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. | | | | |
| **Unit-V** | SoilChemistry-Chemicaland mineralogicalcompositionofsoil,Physicalpropertiesofsoil –texture, bulk density, permeability; Chemical properties – cation exchange capacity,pH,macroandmicronutrients.Chemicalcompounds-detergentsandbleachingagents,Hydrocarbons,PAH,PCBs,chlorofluorocarbons,pesticides. | | | | |
| **ReferenceandTextbooks**:  BalramPani,(2007)*TextBookofEnvironmentalChemistry*,I.K.InternationalPublishingHousePVT.Ltd.  DaraS,MishraD.D(2006).*ATextbookofEnvironmentalChemistryandPollutionControl*.S.ChandPublication.  GaryW.VanLoon,StephenJ.Duffy(2017).*EnvironmentalChemistry:Aglobalperspective*.  4thEdition.OUPOxford.  GirardJ.E.(2015)*PrinciplesofEnvironmentalChemistry*.  JulianE.Andrews,PeterBrimblecombe,TimD.Jickells,PeterS.Liss,BrianReid(2013).*AnIntroductiontoEnvironmentalChemistry.*Wiley-BlackwellPublication.  Rao,C.S.(2018)*EnvironmentalPollutionControlEngineering*,3rdEdition,NewAgeInternational(P)LtdPublishers. | | | | | |

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| **Outcomes** | Onsuccessfulcompletionofthecourse,thestudents   * HaveknowledgeofbasictheoriesandproblemsofEnvironmentalchemistry * Describeimportantchemicalreactionsandcyclicprocessesofchemicalspeciesintheatmosphere,hydrosphereandinlithosphere * Demonstrateknowledgeofchemicalprinciplesofvariousfundamentalenvironmentalphenomena * Applybasicchemicalconceptsinunderstandingthebehaviorofpollutants * Analyzechemicalprocessesinvolvedinair,waterandsoilenvironmentalproblems * Knowthedifferenttypesoftoxicandhazardoussubstancesandanalyzetheir   toxicologicalinformation |

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| **Semester-I** | | | | | |
| **Coursecode:**  22MES1P1 | | **CoreCourse-4** | **T/P** | **C** | **H/W** |
| **Lab-I:EcologicalMethods,EnvironmentalPollutionand**  **EnvironmentalChemistry** | **P** | **4** | **8** |
| **Objectives** | * Thecoursedemonstratesconceptsinmodernecology,methodstoanalyzepollution   andenvironmentalapplications. | | | | |
| 1. BioticandAbioticComponentAssessment 2. Primaryproductivityofanaquaticecosystem 3. EstimationofGPPandNPP 4. FieldSurveyandSamplingMethods 5. EcologicalDataCollection 6. EcologicalDataInterpretationandPresentation 7. AirPollutionMonitoringTechniques–SPM,GaseousPollutants. 8. Measurementofnoiseatdifferentlocations. 9. Soilsamplingtechniquesanddevices 10. Selectionofsamplingsitesandcollectionofmethodsofsamples 11. DeterminationofEC,turbidity,odourandcolourinwater 12. DeterminationofTS,TDSandTSSinwater 13. DeterminationofAcidityandalkalinityinwater 14. DeterminationofDO,BOD,CODandpHinwater 15. DeterminationofHardnessinportablewater | | | | | |
| **ReferenceandTextbooks**:  Barani TharanBalamurali S (2016). *Environmental Engineering Laboratory Manual*:CreatespaceIndependentPublishingPlatform.  KhopkarS.M.*EnvironmentalPollutionAnalysis*.NewAgeInternational(P)Ltd.,Publication.DarrellS.Vodopich(2009).*EcologyLabManual*.McGrawHill.  GopalanR(2020).*ALaboratoryManualforEnvironmentalChemistry*.DreamtechPress. | | | | | |
| **Outcomes** | Onthesuccessfulcompletionofthecourse,studentswillbeableto   * Studentsgainabilitytosetupbasicandadvancedecologicalsamplingtechniquesindifferentecosystems. | | | | |

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| **Semester-I** | | | | | |
| **Coursecode:**  22MES1E1 | | DSE-I A | **T/P** | **C** | **H/W** |
| **DISASTERMANAGEMENT** | **T** | **4** | **4** |
| **Objectives** | * ToUnderstandbasicconceptsinDisasterManagement&mitigation,DefinitionsandTerminologiesusedinDisasterManagement,understandvarioustypesof   DisastersandtounderstandImpactsofDisastersandRiskManagement. | | | | |
| **Unit-I** | Definition–Hazardsasnaturalprocess-BenefitsandimportanceofdisastersNaturedisaster- creeping disaster- creeping disaster- Death and Damage – Evaluating hazards –Humanresponsetohazards.ChangesinCoastalzone,coastalerosion,beachprotection.  Coastalerosionduetonaturalandmanmadestructures. | | | | |
| **Unit-II** | Majorthreatstocoastalecosystem-Habitatloss-Landslides-Sealevelchange,Degradationofwaterquality,Fisheriesresourcedepletion,Earthquakes,Tsunami,Volcanic activity, Coastal flooding, Cyclones, Erosion,. Sea water intrusion, Cause andpreventivemeasures.ImpactonEnvironmentForecastingandWarningSystem–Disaster  ProfileofIndia. | | | | |
| **Unit- III** | DisasterManagement.PredisasterPlanning-ToningofDisaster–proneareas–prioritization –regulations – protection measures during disaster and Post disaster. ReliefCampOrganization–SurveyandAssessment.DisasterManagementCycle–VulnerabilityAnalysis–DisasterTraining–LegalAspects–casestudiesfordisastersandmanagement.TechnologyforDisasterManagement–RoleofInformationandcommunicationtechnology,GPS,RemotesensingandGeographicInformationsystemin  DisasterManagement. | | | | |
| **Unit -IV** | Disaster Preparedness and Training.CommunityPreparedness inNatural Disasters-Roleofinformation,education,communicationandtraining-Rolesandresponsibilitiesofdifferentnationalandinternationalagenciesandgovernment-NGO,Armedforces,Paramilitaryforces,Communitybasedorganizations(CBO)-ArmyTrainingforDisaster  Reduction–Roleofteamandco-ordination-Trainingneeds. | | | | |
| **Unit-V** | MitigationStrategies:DisasterMitigation–emerging trendsindisaster management-UNdraftresolutiononStrengtheningofCoordinationofHumanitarianEmergencyAssistance,InternationalDecadeforNaturalDisasterReduction(IDNDR),Policyfordisasterreduction,problemsoffinancingandinsurance.Trainingforemergency.  Regulation/guidelinesfordisastertolerancebuildingstructures. | | | | |
| **ReferenceandTextbooks**:  DavidR.Godschalk,*NaturalHazardMitigation:RecastingDisasterPolicyandPlanning*(Editor),TimothyBeatley,PhillipBerke,DavidJ.Bowe,EdwardJ.KaiserCharlesC.Bohl,R.MatthewGoebel,Islandpress:(January1999),ISBN1559636025  NaturalDisasterManagement,TudorRose,6FriarLaneLeicesterLE15RAUnitedkingdom.JeffGroman(2002)TheAtlasofNaturalDisastersby(Author)Publisher:Friedman/Fairfa  Publishing;(March2002).  BryantEdwards(2005):NaturalHazards,CambridgeUniversityPress,U.K.  Sharma,R.K.&Sharma,G.(2005)(ed)NaturalDisaster,APHPublishingCorporation,New | | | | | |

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| Delhi  Carter,NW.*DisasterManagement*:AdisasterManager’sHandbook,AsianDevelopmentBank,Manila.(1992).  Gautam Ashutosh1994.*Earthquake: A Natural Disaster*.Ashok Publishing House.New Delhi.SinghR.B.2006*NaturalHazardsandDisasterManagement*;VulnerabilityandMitigation.  RawatPublications.  JochenZschau,AndreasN.Kuppers(2003). *EarlywarningSystemsforNaturalDisasterReduction*.Springer-Verlag,BerlinHeidelberg. | |
| **Outcomes** | Onthesuccessfulcompletionofthecourse,studentswillbeableto   * UnderstandtheEmergency/DisasterManagementCycle. * DevelopabasicunderstandingofPrevention,Mitigation,Preparedness,ResponseandRecovery |

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| **Semester-I** | | | | | | |
| **Coursecode:**  22MES1E2 | | | DSE-IB | **T/P** | **C** | **H/W** |
| **ENVIRONMENTALLAWSANDPOLICIES** | **T** | **4** | **4** |
| **Objectives** | * Toimpartknowledgeaboutenvironmentallaws,regulationsandpoliciesofIndia   andinternationalenvironmentallaws. | | | | | |
| **Unit-I** | Internationalenvironmentalpolicy–environmentalproblemsandtheirimpactoninternationalsystem,theinstrumentsofinternationalenvironmentalpolicy-Transnationalenvironmentalpolicies–theIndusriverbasin,theGanga–Brahmaputra  riverbasinsystem | | | | | |
| **Unit-II** | Environmentalplanning-conceptsandapproachesandstrategicof environmentalplanningandmanagement.InternationalEnvironmentallaws.NecessityforInternational  EnvironmentalCourt.UnitedNationsEnvironmentProgramme[UNEP]roleoninternationalenvironmentlaws.CasestudiesforInternationalenvironmentaldisputes. | | | | | |
| **Unit- III** | Constitutional and legislative provisions : constitutional provisions and the environment,environmental protection and fundamental rights, judicial remedies and procedures, Tortlaw,publicnuisance,thewritjurisdiction,statutoryremedies,publicinterestlitigation,  classaction,freedomofinformationandtherighttoknow. | | | | | |
| **Unit -IV** | Indian legislation toprotect theenvironment: The water act of1974, The Water Cess actof 1977, Thewildlife Act of1972, the air act of 1981, ThepublicLiability insurance actof1991,thenaturalenvironmentaltribunalactof1995,thenationalenvironmentappellateauthorityactof1997,theminesandmineralsactof1957.Casestudiesoneeach  intheprotectionofforests,riversandwildlife. | | | | | |
| **Unit-V** | TheIndianforestactof1927,theforest(conservation)actof1968,Theatomicenergyact of 1962, The factories act of 1948. The environmental protection act of 1986, Thenationalenvironment appellate authorityact of1997.The forest conservationact1980,Thewildlifeprotectionact1972(2002amendment),-PlasticsWastemanagementRules  2015 | | | | | |
| **ReferenceandTextbooks**:  GurudeepSingh(2005)*EnvironmentallawinIndia*–McMillan,NewDelhi.  ShyamDiwanandArminRosencrany,2001,*EnvironmentallawandpolicyinIndia*,OxfordUniversityPress,NewDelhi.  *PollutionControlLegislations*,Vol.IandII,1999,TamilnaduPollutionControlBoard,Chennai.  NathB.,Hens,L.,Compton,PandD.Devuyst(1998),*EnvironmentalManagementinPractice*,VolI,Routledge,LondonandNewYork.  TheISO14000Handbook:JosephCascio.ISO14004–*Environmentalmanagementsystems*:*Generalguidelinesonprinciples*,systemsandsupportingtechniques(ISO14004:1996(E).ISO14001:*Environmentalmanagementsystems*:Specificationwithguidanceforuse(ISO  14001:1996b(E)).(Internationalorganizationforstandardization–Switzerland). | | | | | | |
| **Outcomes** | | Onthesuccessfulcompletionofthecourse,studentswillbeableto   * Understandenvironmentallegislationandpoliciesofnationalandinternationalregime. * Haveaninsightintomajoractsandrulesapplicableforpollutioncontrolandnaturalresourceconservation. | | | | |

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|  | * developtheskillsneededforinterpretinglaws,policiesandjudicialdecisionsabouttheenvironment. * Knowregulationsapplicabletoindustriesandotherorganizationswithsignificantenvironmentalaspects. * Applythelegislationconceptsforsolvingthelocalenvironmentalproblems. * GetknowledgeofthelegalsystemoperatinginIndia. * Beinapositiontopreparecompliancereportsforgettingenvironmentalclearance * Preparetheenvironmentalmanagementsystemforanorganization. |

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| **Semester-II** | | | | | |
| **Coursecode:**  22MES2C1 | | **CoreCourse-5** | **T/P** | **C** | **H/W** |
| **EnvironmentalMicrobiology** | **T** | **4** | **4** |
| **Objectives** | Thiscourseisdesignedtoprovideabasicunderstandingonmicrobiologyandin-  depthknowledgeofroleofbeneficialandpathogenicmicroorganisminenvironment. | | | | |
| **Unit-I** | Introductory microbiology; Microbiology- organisms in nature &theirimportance: Classificationofmicroorganisms,Criteriaforclassification; nutritionaltypes, ScopeofEnvironmentalMicrobiology;microbialgrowthandmetabolismMicrobialmetabolismenergyproduction,utilizationofenergy&  Biosynthesis.Roleofmicrobesinhumanlifeandenvironment. | | | | |
| **Unit-II** | Diversityofenvironmentalmicrobes–Distribution–microbiologyofaquaticenvironment(fresh,marine andotheraquatic environment),microbiology ofterrestrialenvironment.Aeromicrobiology–outdoorandIndoor,aerosols,Adaptationofmicroorganismstotheairenvironment;extremophiles(archaebacteria,acidophilic,  alkalophilic,thermophilic,barophilicandosmophilicandradiodurantmicrobes). | | | | |
| **Unit III** | Roleofmicroorganisms in natural system and artificialsystem;Influence ofMicrobes onthe Earth's Environment and Inhabitants; interspecies microbial interactions,Ecologicalimpacts ofmicrobes,Symbiosis(Nitrogenfixation andruminant symbiosis); microbialinteractionsinabiofilm,Plant–Microbeinteraction(Beneficialandpathogenic),animal  –microbeinteractions(Beneficialandpathogenic)RoleofMicroorganisminNutrient  cycles. | | | | |
| **UnitIV** | BioindicatororganismsinEnvironment-airwaterandsoil(Bacteria,algae,bacteriophagesandotherorganisms).Standardcriteriaofindication,Bio-indicationofwaterquality(surfaceandgroundwater)–Coliforms-totalcoliforms,E-coli,Streptococcus, Clostridium, Concentration and detection of virus. Microbial pathogensis(Human,AnimalandPlanthealth),Transmissionofpathogenstohigherorganisms–  Bacterial,Viral,Protozoan,andHelminths,Controlofmicroorganisms. | | | | |
| **UnitV** | MicrobialDiversity&SystematicsMolecularbiologymethods-Microbialecology(Metagenomics);Functionalandgeneticdiversityofmicrobialcommunities(DNAheterogeneitybyreannealingdenaturedenvironmentalDNA,ARDRA,measuringmetaboliccapabilitiesusingBIOLOG,microtitreplates,usingDNAprobesandPCR  primers,insituhybridizationofintactcells). | | | | |
| **ReferenceandTextbooks**:  Bertrand,J- C., Caumette, P.andLebaron, P. (2015), *Environmental Microbiology:FundamentalsandApplications:MicrobialEcology,*Springer.  Jjemba,P.K.(2004),*EnvironmentalMicrobiology:PrinciplesandApplications*,SciencePublishersInc.,Enfield.  Maier,R.,Pepper,I.andGerba,C.(2008),*EnvironmentalMicrobiology*,AcademicPress.Mitchel,R.(2009),*EnvironmentalMicrobiology*,2ndedition,Wiley-Blackwell.  Mohapatra,P.K.(2008),*TextbookofEnvironmentalMicrobiology*,I.K.International(P)Ltd. | | | | | |

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| Pepper,I.L.,Gerba,C.P.andGentry,T.J.(2015),*EnvironmentalMicrobiology*,3rdedition,AcademiaPress,Elsevier.  Schmidt,T.M.andSchaechter,M.(2012),*TopicsinEcologicalandEnvironmentalMicrobiology*,3rdedition,AcademiaPress,Elsevier.  Uhrig,B.(2017),*EnvironmentalMicrobiology*,Lulu.comPublisher. | |
| **Outcomes** | Onsuccessfulcompletionofthecourse,thestudents   * understandbasicofmicrobiologyandrecentdevelopmentsinenvironmentalmicrobiology. |

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| **Semester-II** | | | | | |
| **Coursecode:**  22MES2C2 | | **CoreCourse-6** | **T/P** | **C** | **H/W** |
| **EnvironmentalBiotechnology** | **T** | **4** | **4** |
| **Objectives** | * ThecourseintroducesknowledgeofbiotechnologicalapproachesandtechniquesforEnvironmentalmanagementandremediationofvariousenvironmentalpollutants. * impart knowledge of biotechnological approaches and techniques for   Environmentalmanagementandremediationofvariousenvironmentalpollutants. | | | | |
| **Unit-I** | **Emergingtechnologyforbioremediation**-RestrictionendonucleasesRecombinantDNATechnology,techniquesofrestrictionmapping-vectors-plasmidPBR322andLamdaphage,cosmidconstructionofchimericDNA,GenomicandcDNAlibraries-PolymeraseChain Reaction (PCR) and development ofgene probes for environmentalremediation*:*useofgeneticallyalteredmicroorganismsforfieldbiodegradationofhazardousmaterials.Insitutechnologies,Ex-situtechnologies.Suicidegenes.Micro-  electromechanicalsystems(MEMS),Genosensortechnology. | | | | |
| **Unit-II** | **Microbial biodegradation-** Xenobiotic compounds: Aliphatic, Aromatics, PolyaromaticHydrocarbons,Polycyclicaromaticcompounds,Pesticides,detergents,Surfactantsandmicrobial treatment of oil pollution. Microbial Systems for Heavy Metal Accumulation,Biosorption&detoxificationmechanisms,oilspills,plasticdegradationby  microbes.phytoremidiation. | | | | |
| **Unit- III** | **BiotechnologyforResourceManagement-**NewBioremediationTechnologiestoRemoveHeavyMetalsandRadionuclides;Oilfieldmicrobiology;Improvedoilrecovery;Roleofenvironmentalbiotechnologyinresourcemanagement–Bioremediation–energyproduction-mineralandenergyrecovery,BiosensorTechnologyformonitoringpollutants-Planningandmanagementofbioremediationand  environmentalbiotechnologyprocesses. | | | | |
| **Unit -IV** | **IndustrialBiotechnology**-FermentationTechnology-DesignofImmobilizedEnzymeReactors–Packed–bed,Fluidized-bedandMembranereactors-Applicationandadvantages.ApplicationsofEnzymesfood,health,andotherindustries.inDesignofenzymeelectrodesandtheirapplicationasbiosensorsinindustry,healthcareandenvironment  **Agriculturalbiotechnology-**EvolutioninAgriculture-BiotechnologyandSustainableProduction.(biofertilizers–Rhizobium,Azolla;Biopesticides-Btinsecticide.)modernagriculture-strategiesforengineeringherbicide-Resistanceenvironmentimpact.Advantagesandapplicationsofbiofertilizers,biopesticidesandGMcrops.**ForestryandBiotechnology-**micro-propagation;Somaclonalvariations;Inductionofgeneticvariabilityandheriditability;Conservationofendangeredspecies;Biotechnology  inpreservationofbio-diversity;Insituandexsituconservationthroughgenebanks. | | | | |
| **Unit-V** | **Bioethics,BiosafetyandIPR-**Bioethics–ethicalconcernsofbiotechnologyresearchandinnovationofGeneticallymodifiedplants,animalsandmicrobes,genetically  modifiedfood,stemcellresearch.PotentialeffectonEnvironmentandHumanhealthby | | | | |

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|  | transgenic plants-Risk assessment, regulation and containment - Human genome project -ICMR Ethical Guidelines for Biomedical Research on Human Subjects. Objectives andsalientfeaturesofBiosafteyguidelinesandregulations-RightsIntellectualproperty  rights-TRIP-GATT-Plantvarietyprotection. | |
| **ReferenceandTextbooks**:  ChatterjiA.K(2011).*IntroductiontoEnvironmentalBiotechnology*.PrenticeHallIndiaLearningPrivateLimited.  Evano,G.H.andFurlong,J.C.(2004),*EnvironmentalBiotechnology*–TheoryandApplication,JohnWiley andSons,USA.  GarethM.Evans,JudithC.Furlong(2012).*EnvironmentalBiotechnology–TheoryandApplication*.2ndEdition.WileyIndiaPvtLtd.  Jjemba,P.K.(2004),*EnvironmentalMicrobiology*–TheoryandApplication,SciencePub.  Inc.,USA.  Olguin,C.J.,Sanchez,G.,Hernandez.E.(2000),*EnvironmentalBiotechnologyandCleanerBioprocesses*,Taylor&Francis.  Pepper,I.L.andGerba,C.P.(2005),*EnvironmentalMicrobiology*-LaboratoryManual,Elsevier,USA.  Ratledge,C.andKristiansen,B.(2003),*BasicBiotechnology*,2ndedition,CambridgeUniversityPress.  ViswanathBuddolla(2017).E*nvironmentalBiotechnology:BasicConceptsandApplications*.AlphaScienceInternationalLtd | | |
| **Outcomes** | | Onsuccessfulcompletionofthecourse,thestudents   * WillobtaintheknowledgeofExistingandemergingbiotechnologicalapproachesinremediationofpollutionandenvironmentalmanagement. * Implement various practical approaches to address environmental issues   relevanttoenvironmentalbiotechnology. |

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| **Semester-II** | | | | | |
| **Coursecode:**  22MES2C3 | | **CoreCourse-7** | **T/P** | **C** | **H/W** |
| **EnvironmentalToxicology** | **T** | **4** | **4** |
| **Objectives** | This course is designed to offer an outline on toxicology, including an introduction of themajor groups ofpollutants,their fatein theenvironment,their disposition inorganismsandtheirmechanismsoftoxicity.Thetoxicityassessmentofpollutantsinbiologicaland  environmentalsystemsisalsoincluded. | | | | |
| **Unit-I** | **IntroductiontoToxicologyandToxicants:**DefinitionofToxicology,ToxicityandToxicants.Classification of toxic agents – natural toxins (Animal,Plant and microbialtoxins)andAnthropogenictoxicants(Chemicaltoxins).Classesofenvironmentaltoxicants;Inorganicions(Metals-Hg,Anions-NO3),Organiccontaminants(HydrocarbonsandPCBs)–Organochlorineinsecticides(DDTandAldrin),Organophosphorusinsecticides(Parathion,CarbomatesandPyrethroids).Detergents,  PharmaceuticalsandPersonalCareProducts. | | | | |
| **Unit-II** | **Entry,DistributionandModeofAction:**RoutesofEntry –Inhalation,Absorption,Ingestion, Injection. Biodistribution, Biomagnification and Biotransformation.Types ofToxicity–Acute,SubacuteandChronic.EffectsofToxicants-Short TermandLongterm.DoseResponseRelationship-LC50,LD50,EC50.OSHAPermissibleExposureLimits(PELS).ModeofAction-ReactionsofToxicantswithTargetMolecules-CovalentBinding,Non-covalentBinding,HydrogenAbstraction,ElectronTransferand  EnzymaticReactions. | | | | |
| **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 andEffects–FattyLiver(Steatosis),LiverNecrosis,Cirrhosis,Cholestasis,Virallike  Hepatitis.NephrotoxicantsandtheirEffects. | | | | |
| **UnitIV** | **SystemicToxicologyII:**NeurotoxicantsandEffects(Neuronopathy,Axonopathy).Effect ofToxicants on Reproductive and Cardiovascular System. Endocrine DisruptingChemicalsandtheirToxicity.Immunotoxicants–MechanismsofImmuno-toxicity,Immuno-suppression,DirectandindirectEffectsofToxicants,ImmuneMediated  Diseases,(HypersensitivityandAllergy) | | | | |
| **UnitV** | **Ecotoxicogenomics,ToxicityTestingandRiskAssessmentofToxicants:**IntroductiontoToxicogenomics,ToxicoproteomicsandMetabolonomics-ModificationofDNA,RNA andProteinMetabolism by Toxicants.GeneExpression Changesby Toxicants-RoleofEcotoxicogenomicsfor Environmental Monitoring andToxicantIdentification.ToxicityTestingMethods–Microbiol,Algal,InvertebratesandAlternativeToxicityTests,AnimalManagementinToxicologicalEvaluation-ExtrapolationandEthics.DefinitionofRiskAssessment,ElementsofRiskAssessment-CategoriesofRiskAssessment–RetroactiveandPredictive,RiskAssessor,RiskManager,HazardIndex,  NASParadigmanditsComponents**.** | | | | |

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| **ReferenceandTextbooks**:  Bertrand,J.C,Caumette,P.andLebaron,P(2015).*EnvironmentalMicrobiology:FundamentalsandApplications:MicrobialEcology*.Springerpublications.  C.H.Walker,S.P.Hopkin,R.M.SiblyandD.B.Peakall,(2006),*PriciplesofEcotoxicology*,ThirdEdition,CRC Press(Taylor& FrancisGroup).  DanielA.Vallero,(2005),*EnvironmentalContaminants-AssessmentandControl*,AcademicPress.  DavidJ.Hojjman,BarnettA.Rattner,G.AllenBurton,Jr.,andJohnCairns,Jr.,(2000),  *HandbookofEcotoxicology*,CRCPress(Taylor&FrancisGroup).  EnvironmentalToxicants-HumanExposureandTheirHealthEffects,MortonLippmann,(2000),John Wiley and SonsPublication.  KatalinGruiz,TamsMeggyesandEvaFenyvesi,(2014),*EnvironmentalToxicology*-EngineeringToolsforEnvironmentalRiskManagement,CRCPress(Taylor&FrancisGroup).  LU’sBasicToxicology(Fundamentals,TargetOrgansandRiskAssessment),SixthEdition,SamkacewandByung-MuLee,(2013),CRCPress(Taylor&FrancisGroup).  MichaelC.Newman,(2001),*FundamentalsofEcotoxicology*,LewisPublishers.  Ming-HoYu,(2004),*EnvironmentalToxicology*–BiologicalandHealthEffectsofPollutants,SecondEdition,CRCPress(Taylor&FrancisGroup).  PepperI.L,GerbaC.PandGentryT.J.(2015).*EnvironmentalMicrobiology*.3rdEdition,AcademiaPress.  RobertBurke,(2000),*HazardousMaterialsChemistryforEmergencyResponders*,LewisPublishers.  Schmidt, T. M. and Schaechter, M (2012). *Topics in Ecological andEnvironmentalMicrobiology*.3rdEdition,AcademiaPress.  Wayne.G.Landis,MingHoYu,3rdEd.(2002)*IntroductiontoEnvironmentalToxicology*,LewisPublishers,CRCpress,NY. | |
| **Outcomes** | Onsuccessfulcompletionofthecourse,thestudentswill   * Get an outline on toxicology, including an introduction of the major classes ofpollutants, their fate in the environment, their disposition in organisms and theirmechanismsoftoxicity. * Know the basis of toxicology and an overview about natural and anthropogenictoxicants * comprehend the entry, distribution and mode of action of the toxicants in theenvironment * explain the effects of toxicants in various systems like respiratory, excretory,reproductiveandcardiovascular. * Betrainedinthefieldoftoxicitytestingmethodsandassessmentsofrisks   causedbytoxicants. |

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| **Semester-II** | | | | | | |
| **Coursecode:**  22MES2C4 | | | **CoreCourse-8** | **T/P** | **C** | **H/W** |
| **Lab-II:EnvironmentalMicrobiology,Biotechnologyand**  **Toxicology** | **P** | **4** | **8** |
| **Objectives** | * Thecourseprovidespracticalguidelinesonconductingexperimentsacrossthe   entirespectrumofenvironmentaltoxicology,biotechnologyandmicrobiology. | | | | | |
| 1. GoodMicrobiologylaboratorypractices:Laboratorysafety(DosandDon’ts), 2. Topreparebasicliquid(Nutrientbroth)andbasicsolidmedia(NutrientAgarandPotatoDextroseAgar)forcultivationofbacteriaandfungi. 3. To learn pure culture techniques used for isolation and purification of microorganisms a. Pourplatemethodb.Spreadplatemethodc.Streakplatemethod 4. To perform different staining methods to study morphological and structural characteristics ofbacteria and fungi a. Simple staining b. Gram Staining c. Fungal staining (Lacto-phenol cottonblue) 5. Enumerationofmicrobesfromsoilandair 6. ExaminationofMycorrhizae–VAM 7. IsolationofgenomicDNAfrombacteria 8. IsolationofgenomicDNAfromplant 9. IsolationofgenomicDNAfromanimaltissue 10. Surveyofdegradativeplasmidsinmicrobesgrowinginpollutedenvironment 11. Estimationofreducingsugarsintoxicwaste. 12. Estimationofproteinfromtoxicwaste. 13. Casestudiesonenvironmentaleffectsofpesticides. 14. Modelingofpollutantdispersion. 15. Toxico-genomicandpharmaco-genomicevaluationofpollutants. | | | | | | |
| **ReferenceandTextbooks**:  AlexanderN.GlazerHiroshiNikaido(1995)*MicrobialBiotechnology*,WHFreemanandCompany,NY,USA.  BernaralR.GlickandJackJ.Pastemak(1994)*MolecularBiotechnology:PrinciplesandApplicationsofRecombinantDNA*,ASMPress.Washington,DCUSA.  Brown,T.A.(1995)Genecloning-*Aintroduction*-Chapman&Hall,London.  David Woolley,Adam Woolley (2013).*AGuidetoPracticalToxicology:Evaluation,Prediction,andRisk*.2ndEdition.TaylorandFrancisPublication.  Dr. Ratna Trivedi(2016). *Practical Manual of Environmental, Microbiology andBiotechnology*.Academicpress.  GlazerandNikaido(1995)MicrobialBiotechnology.WHFreeman&Co.,NewYork.  JayantaKumarPatra,GitishreeDas,SwagatKumarDas,HrudayanathThatoi(2020).A*PracticalGuidetoEnvironmentalBiotechnology(LearningMaterialsinBiosciences)*.Springerpublication. | | | | | | |
| **Outcomes** | | Onthesuccessfulcompletionofthecourse,studentswillbeableto   * Explaintheroleofmicrobesindegradationofenvironmentalpollutants * Acquireskillsinmanipulatingthemicrobesforbiodegradationofpollutants | | | | |

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|  | * Developprocessesforwastebioconversiontovalue-addedproducts. * Become an entrepreneur/researcher in the areas of environmentalbiotechnology. |

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| **Semester-II** | | | | | | |
| **Coursecode:**  22MES2E1 | | | DSE-IIA | **T/P** | **C** | **H/W** |
| **BIOREMEDIATION** | **T** | **4** | **4** |
| **Objectives** | Asanintroductioncourse,itincludesanoverviewofthebioremediationprocess;describe the typical bioremediation strategies for contaminated environment; explore theapplicationsofbioremediationtechnologies;discussthefactorsthatinfluencethebioremediationrates;andintroducesuccesscasesin theapplication ofbioremediation  technologytocontaminatedsites. | | | | | |
| **Unit-I** | Bioremediation - factors affecting bioremediation, types. Organic pollutants - aerobic andanaerobicdegradationoforganicpollutants-degradationofaliphatic,aromatic,polyaromaticandchlorinatedcompounds,biotechniquesforairpollutionabatementand  odourcontrol-bioscrubbers,biobeds,biotricklingfilters,biodeterioration. | | | | | |
| **Unit-II** | Bioremediationofinorganicpollutants-Heavymetalsandradionuclides-microbialinteraction with metallic elements - molecular mechanism of metal resistance, biosorptionandbiotransformationofmetalsandradionuclides,biomining,Nitrate-Nitrificationand  denitrification-Phosphate-BiologicalPhosphateremoval,Phytoremediation. | | | | | |
| **Unit III** | Waste utilization and management, Bioplastics, Biosensor technology, Biofuels,  Vermitechnology,SCP,Biofertilizer. | | | | | |
| **UnitIV** | Moleculartechniquesinbioremediation–pathwayconstruction–Biochemicalbackground,Operonderegulation,Vectors,Hybridpathwaysandenzymes,Noncatabolic  genesforcatabolicpathwayconstructuion,Rationalenzymeredesign. | | | | | |
| **UnitV** | GEM–degradativeplasmids,promotingGEMsurvival–implicationsforbioremediation, preventing GEM survival – suicide contaminant systems – GMOs in foodproduction–transgeniccrops–Biosafety–Bioethics–Patents–Patentlawsand  regulation. | | | | | |
| **ReferenceandTextbooks**:  Ronaldl.CrawfordandDon.l.Crawford,1996,*Bioremediation*–PrinciplesandApplications,CambridgeUniversityPress.  NuzhatAhmed,FouadM.QureshiandObaidY.Khan,2006*IndustrialandEnvironmentalBiotechnology*–HorizonPress  Paul.A.Rochelle,2001*EnvironmentalMolecularBiology*,HorizonPress. | | | | | | |
| **Outcomes** | | Onsuccessfulcompletionofthecourse,Studentswill   * Understandthenatureandimportanceofbioremediation; * Knowtheinfluenceofsitecharacteristicstobioremediationrates; * Haveknowledgeoftheimpactsofcontaminantcharacteristicstobioremediationprocess * Understandtheuseofbioremediationinrealworldapplications | | | | |

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| **Semester-II** | | | | | |
| **Coursecode:**  22MES2E2 | | DSE-IIB | **T/P** | **C** | **H/W** |
| **BIODIVERSITYANDCONSERVATION** | **T** | **4** | **4** |
| **Objectives** | Biodiversitydescribestheorganismsinthenaturalenvironment,whichprovidetheecosystem services that form our natural capital: fresh water, clean air, soil fertility andbiologicalpestcontrol.Biodiversityisfundamentaltothefuturesustainabilityoftheworld’snaturalresources.Conservationofbiodiversity,oneconomicgroundsalone,  needstobecomecorebusinessinthemanagementofournaturalresources. | | | | |
| **Unit-I** | **Scope and Constraintsof Biodiversity Science :**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. | | | | |
| **Unit-II** | **Species Diversity:** 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. | | | | |
| **Unit-III** | **HabitatsandEcosystem:**Historyofecosystemecology,HumaninducedEcosystemchange,UrbanEcosystemClassification–Ecosystemmapping,tropicalforests,grasslands,wetlands,coralreefs,mangroves;Habitatlass:Habitatdestruction–Fragmentationanddegradation –desertification –Habitatrestoration;InvasiveSpecies:theirintroductionpathways,biologicalimpactsofinvasivespeciesonterrestrialandaquaticsystems;ImpactsofExploitationonTargetandNon-targetTerrestrialand  AquaticspeciesandEcosystems. | | | | |
| **Unit -IV** | **ValuesofBiodiversity**Instrumental/Utilitarianvalueandtheircategories,Directusevalue;Indirect/Non-consumptiveusevalue,IntroductiontoEcologicalEconomics;MonetizingthevalueofBiodiversity;IntrinsicValue;Ethicalandaestheticvalues,Anthropocentrism,Biocentrism,EcocentrismandReligions;IntellectualValue;EconomicsofEcosystem,GreenRevolution,FoodPlants,medicinalandornamental  plants,animaluses–livestockandfisheries. | | | | |
| **Unit-V** | **ConservationandManagement**NationalLegislation–ProtectionofWildfloraandFauna-ProtectionofNationalHabitats- NationalandInternationalProtectedAreas–CurrentPracticesinConservation-in*situ*Conservationand*exsitu*ConservationofThreatened Species –BiodiversityAct2002 -Forestprotection Act-ForestconservationAct1980-MultilateralTreaties–BiodiversityConventions.Environmentalethics–Biodiversity- Socio–PoliticalPerspective;CommunityconservedAreas(CCAs)-  Range sand significance of CCAs. Conservation and sustainable development - | | | | |

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|  | traditionalsocieties-Governmentactionlocallegislation-nationallaws-NationalBiodiversityActandNationalBiodiversityAuthority.Internationalapproachestoconservationandsustainabledevelopment-Ongoingproblems-possibleresponses-  roleofconservationbiologists. | |
| **ReferenceandTextbooks**:  Chaudhuri,A.B.andD.D.Sarkar(2003),*MegadiversityConservation,flora,FaunaandMedicinalPlantsofIndia’shotspots,*DayaPublishingHouse,Delhi.  Singh,M.P.,B.S.SinghandSomaS.Dey(2004),*ConservationofBiodiversityandNaturalResources*.DayaPublishingHouse,Delhi.  DadhichL.K.andA.P.Sharma(2002),*Biodiversity–StrategiesforConservation*,APHPublishingCorporation,NewDelhi.  Khan,T.IandDhariNAlAjmi(1999),*GlobalBiodiversity*–ConservationMeasure,PointerPublishers,Jaipur.  Krishnamurthy,K.V(2003),*AnAdvancedTextbookonBiodiversity*–PrinciplesandPractice,OxfordandIBHPublishing,NewDelhi.  T.B.1:Krishnamurthy,KV.,2003,*AnadvancedTextbookonbiodiversity*,OxfordandIBHBook.Co.,NewDelhi.  T.B.2:Hall,BK.andHallgrimsson,B.,2014.*Evolution*,5thEdition,JohnesandBartlettIndiaPvt.Ltd.New Delhi.  Ridley,M.,,2004,*Evolution*,3rdEdition,BlackwellScienceLtdaBlackwellPublishingcompany,USA. | | |
| **Outcomes** | | Protected and restored marine and estuarine ecosystems. Controlled invasive species,Mitigateddrylandsalinity,Promotedecologicallysustainablegrazing,Minimizedimpactsofclimatechangeonbiodiversity,Maintainedandrecordindigenouspeoples’  Ethnobiologicalknowledge,Improvedscientificknowledgeandaccesstoinformation. |

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| **Semester-III** | | | | | |
| **Coursecode:**  22MES3C1 | | **CoreCourse-9** | **T/P** | **C** | **H/W** |
| **BIOSTATISTICSANDRESEARCHMETHODOLOGY** | **T** | **4** | **4** |
| **Objectives** | ToimpartunderstandingontheconceptsofbiostatisticsandtoimprovetheComputingknowledgeofthestatisticalmethodsrelatedtoenvironment | | | | |
| **Unit-I** | **Basicstatistics:**SchemesforClassification-Tabulationandrepresentationofdata–sciencepopulationnumericaldatainscience-Samplingtheory–Measuresofcentraltendency and dispersion–Correlation andregression-Analysis-Probability –Theoreticaldistribution-Analysis of one way variance-Methods of analyzing oceanographic data andfilteringofscientificdata | | | | |
| **Unit-II** | SamplingMethods:Probabilitysampling,randomsampling,systematicsampling,stratifiedsampling,clustersamplingandmultistagesampling.Non-probabilitysampling:  conveniencesampling,judgementsampling,quotasampling. | | | | |
| **Unit-III** | TestsofSignificance– Mass and alternativehypothesis– errorlevelof significance–Equal and Unequal Sampling - t, z, x2 test,Analysisofvariance – One way ANOVA–Two way ANOVA – Regression and correlation - simple and multiple. Introduction toenvironmentalsystemanalysis,Approachestodevelopmentofmodels,modelsof  populationgrowthandinteraction-variousmodels. | | | | |
| **Unit-IV** | Applications of Computer in Environmental Science and Management –Data Analysisusingpackages(SPSS):Editing,DataTabulation,Descriptivestatistics,MultivariateAnalysis – Correlation – Regression –Cluster analysis – Factor Analysis -PCA,GraphPlotting,Computationaldatabasesandenvironmentalmanagement. | | | | |
| **Unit-V** | Scientificdocumentation:Methodsofliteraturecollection,design,planningandexecution of investigation, Preparation of scientific documents, general articles, researchpapers,reviewarticles,editingofresearchpapers,methodsofcitation,collectionofliteratures,including web based methods,bibliography andthesiswriting.Presentationtechniques,effectivecommunicationskill. | | | | |
| **ReferenceandTextbooks**:  ArvindShendeandVijayUpagade(2010).*ResearchMethodology*.S.ChandPublications.  Bliss,G.I.(1970),*StatisticsinBiology*.McGrawHillBookCompany,Vol.IandII.NewDelhi.  ByronSGottfried(1996),*ProgrammingwithC*,HillPublishingCo,NewDelhi.GuptaS.P.(2014).*StatisticalMethods*.SultanChand&SonsPublications.  Gupta,S.P.(1996)*StatisticalMethods*,SultanChand&SonsPublications,NewDelhi.Haynes,R(1982)*EnvironmentalScienceMethods*,Chapman&Hall,London.  Khan,I.AandKanum,A.,(1994)*FundamentalsofBio-Statistics*,UkaazPublication,Hyderabad. | | | | | |

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| Kothari,C.R(1996),*QuantitativeTechniques*,VikasPublishingHousingPvtLtd,Hyderabad.  Kothari,C.R.,(1989),*ResearchMethodology–MethodsandTechniques*.WileyEastern,NewDelhi.  Miller,J., (1989), *Statistics for Advanced Level*,Cambridge UniversityPress.RastogiV.B(2009).*FundamentalsofStatistics*.ANEBooks.  Snedcor,G.W.andCochran,W.G.(1982),*StatisticalMethods*,AcademicPress.Vittal,R.R.(1986)*BusinessMathematicsandStatistics*,MurghamPublications.  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:BasicConceptsandMethodologyfortheHealthSciences*.10thEdition.WileyPublication. | |
| **Outcomes** | Onsuccessfulcompletionofthecourse,thestudents   * Knowthetypesofresearchandscientificdatabases,reportwritingandplagiarism. * Chosetheresearchthattheywanttocarryout. * Identifyanddesigntheirresearchproblems. * Understandtheprinciplesofresearchmethodsandinstrumentsrequiredfortheir researchexperiments. * Applytheirknowledgeoninstrumentationforenvironmentalanalysis,andfield   worksanddatacollection. |

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| **Semester-III** | | | | | |
| **Coursecode:**  22MES3C2 | | **CoreCourse-10** | **T/P** | **C** | **H/W** |
| **RemoteSensing&GIS** | **T** | **4** | **4** |
| **Objectives** | ToteachtheprinciplesandapplicationsofspatialinformationtechnologiesvizRS,GPSandGISaboutthedistributionofresources.Togivehands-ontrainingontheusesofGIS  softwareinenvironmentalstudies. | | | | |
| **Unit-I** | Elements of photographic systems and computer applications. Land stat. IRS and othersatellite systems- satellite data. Principles involved in thermal IR image and microwaveimageinterpretation.ApplicationsofdifferenttypesofimagesinearthSciences,EnvironmentalSciences,Archeology,Marinestudies,Forestry,Soils,Hazard  managementetc. | | | | |
| **Unit-II** | Conceptsandfoundationsofremotesensing-Historyofremotesensing-Electro-magneticenergy–Propertiesandinteractionwiththeearth.Atmosphericwindows.Black,whiteandgreybodies,sourcesofEMR.Imageinterpretations.Aerialphoto-classificationbasedonattitudeofcameralens,distortionscausedduetoflightirregularities,overlaps,scale,reliefdisplacementanditseffects.Photorecognition  elements.Differenttypesofphotographs | | | | |
| **Unit-III** | Introductionto GeographicalInformation SystemsandGISsoftware,FundamentalsofGIS: Layers and features, Raster/Vector- Georeferencing and projection, Spatial data andGISbasics;Dataattributesandspatialtopology,Projection/Imageregistration,  Digitizationanddataattributes-mapdatarepresentation,GPS. | | | | |
| **Unit-IV** | 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. | | | | |
| **Unit-V** | Remotesensingapplications–ImpactAssessment–PollutionMonitoring–Water–Air  –Ocean Pollution – Land Degradation – Desertification – Industry – Mining –GroundWaterModeling–DamageAssessment–CoastalandMarineapplications–FutureSensors–SatelliteSystem–ENVISAT–MeghaTropiques–TRMM–EOSMissions–  IntegralEarthObservationStudies–GlobalChange-Casestudies. | | | | |
| **ReferenceandTextbooks**:  Barrett,E.CandCurtis,L.F(1982).IntroductiontoEnvironmentalRemoteSensing,BasudebBhatta(2008).*RemoteSensingandGIS*.OUPIndia.  Danson,F.MandPlummer,S.E(1995),AdvancesinEnvironmentalRemoteSensing,SpaceRemoteSensingSystems–AnIntroduction,Chen,H.S(1985).  Fischer,M.MandNijkamp,P(1993).GeographicInformationSystems,SpatialModelingandPolicyEvaluation,Springer–Verlag.  Jensen(2013).*RemoteSensingoftheEnvironment:AnEarthResourcePerspective*.PearsonEducationIndia.  KramerJ.Herbert(2002),ObservationofEarthanditsEnvironment–SurveyofMissionsandSensorsSpringer-Verlag.FundamentalsofRemoteSensing,GeorgeJoseph(2003), | | | | | |

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| UniversitiesPress(India)Ltd.,Hyderguda,Hyderabad  MartinWegmann,BenjaminLeutnerandStefanDech(2016).*RemoteSensingandGISforEcologists:UsingOpenSourceSoftware(DataintheWild).*PelagicPublication.  Muralikrishna,I.V(1995).RemoteSensingandGISforEnvironmentalPlanning,Tata-McGraw Hill.  Roody,G.MandCurran,P.J.(1994).EnvironmentalRemoteSensingfromRegionalandGlobalScales,  Singh,R.B(1992),EnvironmentalMonitoring:ApplicationsofRemoteSensingandGIS,GeocarthoInternational Centre,HonkHong.  WilliamKPratt(2001),DigitalImageProcessing,JohnWiley&Sons. | |
| **Outcomes** | Onsuccessfulcompletionofthecourse,studentscan   * recognizethatRemoteSensingandGeographicInformationSystem(RS-GIS)canbeapowerful toolforgeospatialanalysis. * Acquaint adequate knowledge on principles and basic concepts ofenvironmentalgeoinformatics * UnderstandthebasicconceptsofGISanditsmechanisms * KnowthevarioustypesofGPSsystems * Learnstointerpretsatelliteimages * Understand Image Classification Techniques, Imageenhancementandinterpretationmethods * UseGPSforvariousenvironmentalapplications. * AbletoapplythetoolsofremotesensingandGISforenvironmentaldisastermanagementandconservation |

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| **Semester-III** | | | | | |
| **Coursecode:**  22MES3C3 | | **CoreCourse-11** | **T/P** | **C** | **H/W** |
| **ENVIRONMENTALIMPACTASSESSMENT** | **T** | **4** | **4** |
| **Objectives** | This course tells about the need ofindustry and society to predict and includeenvironmentalconcernsandriskswhiledevelopingprojects.Thecoursealsodescribesthemoderntoolsandtechniquestoevaluatetheenvironmentalimpactsandoutlines  variousmanagementoptionsneededtomitigatetheserisks*.* | | | | |
| **Unit-I** | **Fundamental of EIA:** Definition and Evaluation of EIA in India – Types of Impact-Characteristics - Steps of EIA- Sustainable Development- Framework for EIA, Screening,ScopingandBaselineStudies,SignificanceandImportanceofImpacts,ImpactPrediction-MitigationAspects-AssessmentofAlternatives,PublicHearing,DecisionMaking-TechniquesforAssessmentofImpactsonPhysicalResources,Ecological  Resources,HumanuseValuesandQualityofLifeValues. | | | | |
| **Unit-II** | **EIAMethodologies:**ChecklistMethodologies-AdhocMethod-NetworkMethods-MatrixMethods-MapOverlayMethod-PreparingEIA-InteractingParametersInteraction-EnvironmentandDevelopmentActivities-ComparativeStudiesonMethodology.PredictionandAssessmentofImpactsonBiological,SurfaceWaters,  GroundWater,Air,Noise,RadiationHazards. | | | | |
| **Unit III** | **EnvironmentalLawsandActs:**EnvironmentalPolicies-NationalandInternationalTrends, Changes in Global Perspective, International Treaties. National Policies: NationalEnvironmental Policy, National Forest Policy, National Water Policy, Rehabilitation andResettlementPolicy;EvolutionofEnvironmentalLegislationinIndia,LegalProvisionsfor Environmental Protection; Various Acts, Rules and Regulations. Notifications Issuedunder Various Acts and Rules. Environmental Standards, Criteria for Standards Setting.PublicLiabilityInsuranceActandLegalAspectsRelatingtoHazardousandToxic  Substances.RoleofNationalGreenTtibunals. | | | | |
| **UnitIV** | **EnvironmentalEthics:**ImplementationofInternationalEmissionTrading,ResourceConsumptionPatternsandtheneedforEquitableUtilization-Equity-DisparityintheNorthern and Southern Countries, Urban and Rural Equity Issues- The need for GeneralEquity,Preserving Resources for Future Generation- TheRights of Animals-Preparationof Environmental Management Plan and Criteria for Selection of Environmental Factors,Alternatives-PoliciesofWorldSummit1972,RIOConferenceAgenda21,Montreal  Protocol,KyotoProtocol,ClimateChangeMitigation. | | | | |
| **UnitV** | **CaseStudies:**LandClearingProjects-DamSites-EIAforAquaculture,Steel,Mines,HydroThermal,Nuclear,OilandGasbasedPowerPlants-HighwayProjects-Industrial  Projects.DamagetoCoralReefsinOceans. | | | | |
| **ReferenceandTextbooks**:  BregmamJ.I(1999),EnvironmentalImpactStatements,LewisPublishers,London.  CharlesH.Eccleston(2011).*EnvironmentalImpactAssessment:AGuidetoBestProfessionalPractices*.CRCPress.  EcclestonC.H,(2000),EffectiveEnvironmentalAssessment,LewisPublishers,London. | | | | | |

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| EranchBharucha,(2005),TextbookofEnvironmentalStudies,UniversityGrantsCommission  JaneHolderandMariaLee,(2007),EnvironmentalProduction,LawandPolicies,SecondEdiction.  JohnGlasson(2005),IntroductiontoEnvironmentalImpactAssessment,NaturalandBuiltEnvironmentSeries.Routledge,TaylorandFrancis.  Khandeshwar S.R, Raman N.S,Gajbhiye A.R(2019). *Environmental Impact Assessment*.  DreamtechPress**.**  LarryW.Canter(2013),EnvironmentalImpactAssessment,JohnWileyandSons.RamachandranS(2019).*EnvironmentalImpactAssessment*.AirwalkPublications.  SingletonR,CastlePandSortD(1999),EnvironmentalAssessment,ThomasTelfordPublishingLondon.  SureshK.Dhameja,(2005),EnvironmentalScienceandEngineering,PublishedbySanjeevKumarKataria,Delhi. | |
| **Outcomes** | Onsuccessfulcompletionofthecourse,studentscan   * UnderstandthescopeofEIA * LearnttypesandmethodsofEIAprocess * Developedfactorscorrelationskills * IdentifytheroleofEIAinsustainableenvironmentmanagement * ImprovedtheknowledgeaboutEIAsignificanceandmagnitude * Involvedeconometricvaluesonlevelofimpact * Developedinteractionmatrixbetweenvariables * LearntnationalandinternationalprotocolsonEI |

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| **Semester-III** | | | | |
| **Coursecode:**  22MES3C4 | **CoreCourse-11** | **T/P** | **C** | **H/W** |
| **Lab-III:Biostatistics&Researchmethodology,Remote**  **Sensing&GISandEIA** | **T** | **4** | **8** |
| **Objectives**   * Thecoursedealswithenvironmentalaudit,GISdataqualityissues,GISdataanalysis,integrationandlinkageofRemoteSensingandGISbesidesincludingstatisticaltoolsusedin   research. | | | | |
| 1. Calculationofmean,medianandmode, 2. Calculationofstandarddeviation. 3. StatisticalDataAnalysis–Mean,StandardDeviation,StandardError 4. StatisticalData-AnalysisofVariance(ANOVA 5. PreparationofsimpleVectormap,ToposheetreadingandGPSfieldsurvey. 6. VisualInterpretationofGeomorphicfeaturesfromtheSatelliteimageandAerialphotographs 7. ToposheetandSatelliteImageryAcquisition 8. Georeferencingoftoposheet/SatelliteImagery 9. CreationofVectorLayers 10. RasterImageProcessing 11. ImageClassificationTechniques 12. StudyMapRepresentation/Creation 13. Casestudiesoneffectiveutilizationofenvironmentallaws:oilrefineries,petrochemicalindustry. 14. Comparativeanalysisofvariousmegabuildingprojectsanditsimpactassessment. 15. Impactassessmentofgreenbelts. 16. Visits-sanctuaries,reserves 17. PollutionControlBoardVisitsandReports | | | | |
| **ReferenceandTextbooks**:  ArvindShendeandVijayUpagade(2010).*ResearchMethodology*.S.ChandPublications.  CharlesH.Eccleston(2011).*EnvironmentalImpactAssessment:AGuidetoBestProfessionalPractices*.CRCPress.  GuptaS.P.(2014).*StatisticalMethods*.SultanChand&SonsPublications.  MartinWegmann),BenjaminLeutnerandStefanDech(2016).*RemoteSensingandGISforEcologists:UsingOpenSourceSoftware(DataintheWild).*PelagicPublication. | | | | |
| **Outcomes**   * On successful completion of the course, Students gain knowledge about mapping technology,conceptsofmapsandallrelevantterminologywhicharenecessaryforabeginnertodevelophisskillsin thisnewand upcoming technology. | | | | |

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| **Semester-III** | | | | | | |
| Coursecode:  22MES3E1 | | | **DSE-IIIA** | **T/P** | **C** | **H/W** |
| **Instrumentation&AnalyticalTechniques** | **T** | **4** | **4** |
| **Objectives** | * The purposeof this course isto introduce knowledge and skills in analysis ofenvironmental pollutants in environmental matrices, including extraction, samplepreparationandinstrumentationsanalysis, theoryandtechniquesinquantitative   andqualitativemethods. | | | | | |
| **Unit-I** | PrinciplesandapplicationofSpectrophotometry-UV-Visiblespectrophotometry,Spectrofluorimetry,Titrimetry,Gravimetry,Colourimetry,Infraredspectrophotometry,NMR,ESR,Microscopy-phase,lightandflourscencemicroscopes,Scanningand  Transmissionelectronmicroscopes. | | | | | |
| **Unit-II** | Chromatographictechniques-Paperchromatography,thinlayerchromatography,ionexchangechromatography,Columnchromatography,Atomicabsorptionspectrophotometry, cytophotometry and flow cytometry, Fixation and staining, PrinciplesandtechniquesofnucleicacidhybridizationandCotcurves,Principleofbiophysicalmethodusedforanalysisofbiopolymerstructure,Hydrodynamicsmethods,Plasma  emissionspectroscopy. | | | | | |
| **Unit-III** | Electrophoresis,SDS-PAGE,Agarosegelelectrophoresis,solidandliquid  scintillation,autoradiography,X-rayflorescence,Flamephotometry,Gas-liquidchromatography,Highpressureliquidchromatography,Ultracentrifugation | | | | | |
| **Unit -IV** | Conductometry,voltammetry,turbidimetry,pHmeter,meteorologicalmonitoringdevices,portablegasanalyser,calorimeter,Neutronactivationanalysis. | | | | | |
| **Unit-V** | Methodsformeasuringnucleicacidandproteininteractions,DNAfingerprinting,MolecularmarkersRFLP,AFLP,RAPD,Sequencingofproteinsandnucleic  acids,southern,northern,westernblottingtechniques,PCR-polymerasechainreaction. | | | | | |
| **ReferenceandTextbooks**:  Uppadahay,A.,Uppadahay,N.andandNath,N.(2016),BiophysicalChemistry,Principlesand Techniques,HimalayaPub.House,NewDelhi.  Sawyer,C.N.,McCarty,P.L.andParkin,G.F.(2002),ChemistryforEnvironmentalEngineeringand Science,McGraw-HillEducation  Rupa,H.H.andKrist,H.(1998),LaboratoryManualfortheExaminationofWater,Wastewaterand soil,VC HPublication,NewYork.  Sharma,B.K.(2001),InstrumentalMethodsofChemicalAnalysis,GoelPublishingHouse,Meerut,India. | | | | | | |
| **Outcomes** | | Thestudentsonexposuretothiscoursewillbeableto   * Understandthebasicsandrequirementofenvironmentalanalysis * Understandtheenvironmentalqualityparameterstobemonitoredanddetermined * Knowtheroleofsamplepreparationinenvironmentalanalysis * Understandtheinstrumentaltechniquesandmethodsofanalysis | | | | |

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| **Semester-III** | | | | | |
| **Coursecode:**  22MES3E2 | | **DSE-IIIB** | **T/P** | **C** | **H/W** |
| **ENVIRONMENTALEDUCATION** | **T** | **4** | **4** |
| **Objectives** | * Thecourse focusesonIntroductiontobasicprinciplesof environmentalhealthand safety practices and creating awareness of public and occupational health andsafety requirements associated with the environment. The purpose ofthis course istounderstandtheroleofenvironmentalhealth,protection,safetyatwork,   occupationalhealthandsafety,complianceandbestpractices. | | | | |
| **Unit-I** | **Definition,concept,policy,historyandpractices**:Whatis environmentaleducation-Majorrequirementsofenvironmentaleducation-Interdisciplinary,Psycological,culturalandphysical–Interrelatedness–Flexibility–Nondogmatic-Emphasisonproblemsolving-Practice what you preach-present status- : history, Primary level, secondary level,thirdlevel,andtrainingforprofessionals.ContentofenvironmentalEducation-Philosophyandenvironmentalethics-Politicalsensitivities–Scientificethicsand  Bioethicsinmangroveenvironment–Endangeredspecies-Animalcruelty. | | | | |
| **Unit-II** | **Role of institution**: Teachers preparation and curriculum development for environmentalEducation-Environmentaleducationschoollevel,Universities,R&DInstitutions-Educationforphysicalplanners-Environmentalmanagementeducation –Teaching andlearning strategies for environmental education-Role of non-governmental organization inEnvironmentalEducation–Roleofregional,globalorganizationsinvolvedinlivingand  non-livingresourcesanditsmanagementprogramme. | | | | |
| **Unit- III** | **Community and environmental education.** Coastal rural development- Women’s role –poverty and environment – Population education and its relationship with environmentaleducation- Environmental awareness among children of rural and non-formal educationcentres-Communitybasedresourcemanagement.EnvironmentalHazards:Causesandeffectsofenvironmentalhazards,effectofhumanactivitiesonenvironment-environmental pollution - global and local (Soil pollution, water pollution, air pollution,noisepollution)-Green Houseeffect–Ozonelayer depletion–acidrain, pillar melting,riseofsealevelandtheirimplications-Mitigationeffortsevironmentalprospective-  Internationalco-operation-SupportPoliciesandsystems. | | | | |
| **Unit -IV** | **Massmediainenvironmentalandeco-tourism:**Radio-Television–Newspapers–Cinema-PosterandBanners-Manmedia-Publicinteractionmodels-Evaluationofenvironmentaleducation.Eco-tourism:Principleandconcept–Ecotourismpotential–Natureconservation–Training,educationawarenessthroughecotourism-Communitybased resource management- Managing the protected area through ecotourism awareness.ConservationStrategyandpolicystatementonenvironmentanddevelopment:Environmentalproblems-Actiontaken,Constraintsandagendaforaction-Development  policies. | | | | |
| **Unit-V** | **SustainableDevelopmentandEnvironmentalAwareness**-Learningtoliveinharmony with nature - environmental education for development,conservation ofsoil,water,forests,wildlife,energyresources,movementtosaveenvironment,eco-friendly  technology-Alternatesourcesofenergy-Wastemanagement-Populationand | | | | |

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|  | environment. | |
| **ReferenceandTextbooks**:  Canter,E.W.(1977):*EnvironmentalImpactAssessment*.McGrawHillCo.,NewYorkFedron,E.(1980):*ManandNature*,ProgressPublishers,Moscow  Kormondy,E.(1991):*ConceptofEcology*,PrenticeHallofIndia,NewDelhi.Odem,E.P.(1975):*Ecology*,OxfordandIBHPublishingCo.,NewDelhi.  Purdom,P.W.&Anderson:*EnvironmentalScience*,CharlesE.MerrilPublishingCo.,  Saxena,A.B.(1996):*EducationfortheEnvironmentalConcerns*,ImplicationsandPractices,RadhaPublication,NewDelhi.  Sharma,P.D.(1993):*EnvironmentalBiology*,Rastogi&Co.,Meerut. | | |
| **Outcomes** | | Onsuccessfulcompletionofthecourse,thestudentsget   * Knowledgeintheconceptsandscope,basicrequirementsforhealthyenvironment,environmentalquality,humanexposureandhealthimpact. * Knowledge of the Industrial pollution and chemical safety in public exposurefrom industrial sources, Hazards by industry major chemical contaminants atworkplace.Industrialenvironmentalaccidents. * KnowledgeaboutEnvironmentalDiseasepresentstudyinFluorosisandAllergies;Epidemiologicalissues. * Knowledge of understand course will equip student with basic knowledge onsafetyissuerelatedwithexplosion,pollutantreleaseinwaterandair,andto   implementmeasureduringoutbreakoffluepidemicatworkplace. |

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| **Semester-IV** | | | | | |
| **Coursecode:**  22MES4C1 | | **CoreCourse-13** | **T/P** | **C** | **H/W** |
| **OCCUPATIONALHEALTHHAZARDS**  **ANDINDUSTRIALSAFETY** | **T** | **4** | **4** |
| **Objectives** | Thestudentsonexposuretothiscoursewillunderstandthedifferenttypesofhazardsdisasterspossibleintheindustries.Focushasbeenmadeonthesafetyandmanageme  practicedinindustriesbyhighlightingcertaincasestudies*.* | | | | |
| **Unit-I** | **HealthHazards**:PhysicalHazards–Noise,RiskFactors,OccupationalDamage,Ioninzing and Non-ionizing Radiation- Types and Effects, Hazards of Microwaves andRadio Waves, Lasers. Chemical Hazards – Introduction– Properties of Chemicals, Dust,Gases, Fumes, Mist, Vapours,Smoke and Aerosols. Route of Entry to Human System.BiologicalandErgonomicalHazards–ClassificationofBiohazardousAgents-Bacterial,  Rickettsial,Chlamydial,ViralFungalandParasitic. | | | | |
| **Unit-II** | **HealthDisorders**:OccupationalDiseases,Silicosis,Asbestosis,Pneumoconiosis,Siderosis, Anthracosis, Aluminosis, Byssinosis, Bagassosis and Anthrax. Heavy Metals -Lead,Nickel,ChromiumandManganeseToxicity,GasPoisoning(CO,Ammonia,H2S)  –TheirEffectsandPrevention. | | | | |
| **Unit III** | **IndustrialSafetyMeasures**:FirstAid–Principles,RulesandTraining,PersonalProtectiveEquipments(PPE)-RespiratoryandNonRespiratoryDevices,MaintenanceofMachinesandEquipments,FireExtinguishers–TypesandHandling,FireDetection  andAlarmSystems,WaterSpraySystemsforExplosions. | | | | |
| **UnitIV** | **Plans, Polices and Rules Related to Industrial Safety**: Threshold Limit Values (TLV),TheFactoriesAct,1948,InternationalLabourOrganization(ILO)Convention,SafetyHealth and Envrionment (SHE), BIS on Safety and Health 15001-2000, OSHA, OHSAS-18001.NationalPolicyonOccupationalSafety,HealthAndEnvironmentAtWork–IndianElectricityAct2003,IndianExplosiveAct–1984.HazardousMaterials  TransportationRules. | | | | |
| **UnitV** | **CaseStudies:**MajorIndustrialDisastersinIndia-TheBhopalGasTragedy1984,Chasnala Mining Disaster 1975, Jaipur Oil Depot Fire 2009,Korba Chimney Collapse2009, Mayapuri Radiological Incident 2010, Bombay Docks Explosion 1994, Disasters intheRestoftheWorld– SpyrosDisaster1978,OppauExplosion,Germany1921,CourrieresMineDisaster,France1906,ChernobylDisaster,Ukraine1986,Halifax  Explosion,Canada1917,BenxihuCollieryExplosion1942. | | | | |
| **ReferenceandTextbooks**:  DellaD.E.,andGiustina,(1996),SafetyandEnvironmentalManagement,VanNostrandReinhold InternationalThomsonPublishingInc.  GoetschD.L.,(1999),OccupationalSafetyandHealthforTechnologists,EngineersandManagers,PrenticeHall.  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,WandRussell,L,(1984),ABCofIndustrialSafety,PitmaPublishingUnited | | | | | |

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| Kingdom. | |
| **Outcomes** | Oncompletionofthecourse,students   * ApplyknowledgeofscienceinthemanagementofIndustrialsafetyandhealth. * Identifyindustrialsafetyandhealthproblems. * Understandprofessionalandethicalresponsibilityinsafetymanagementofindustries. * Learningtodealwiththecontemporaryissuessurroundingoccupationalsafetyandhealth. * Learningtechniquesandcontrolofhazardoussubstances. * Recognizetheneedforaprofessionaldevelopmentinthisfield. * Solvetheproblemsrelatedwithindustrialsafety. * Understandtheimpactofoccupationalsafetyandhealth |

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| **Semester-IV** | | | | | |
| **Coursecode:**  22MES4C2 | | **CoreCourse-14** | **T/P** | **C** | **H/W** |
| **CLIMATECHANGE** | **T** | **4** | **4** |
| **Objectives** | * Toimparttheknowledgeoffundamentalscientificprinciples,conceptsandglobal   perspectiveunderlyingclimaticchange. | | | | |
| **Unit-I** | Climate change – concept of climate change –Atmosphere-atmospheric motion, Earth’srotation:Corioliseffect,globalatmosphericcirculation.HumanImpactsonclimate-greenhousegasemissions,Fossil--‐fuelemissionsscenarios,IPCC.Greenhouseeffect;Water vapor and climate, Carbon cycle.sea level rise - Carbon pools and their relativesignificance.ozonedepletion-stratosphericozoneshieldand Ozonehole–Impactof  ClimateChangeonenvironmentandbiodiversityandtheirimplications. | | | | |
| **Unit-II** | AdaptationandMitigationResponsesandpoliciesofclimaticchanges-Emissionstrading/carboncreditschemes.Internationaladaptationinitiativesandprograms-renewableenergy,greenbuilding,energyefficiencyandreducingconsumption-lowcarboneconomy.Integratedmitigationfordevelopmentandplanningthroughlowemission development strategies - Climate Change and sustainable development.Role ofGovernments,Business,NGOs,otherInstitutionsinadaptingto,andmitigatingclimate  change | | | | |
| **Unit III** | TheClimateChangePolicyFramework-TheMontrealProtocol-ProvisionsoftheUnited Nations Framework Convention on Climate Change (UNFCCC) - structure of theUNFCCC, and different party groups under the convention -Annex I, Annex II and Non-AnnexIcountries.Parisagreement.TheKyotoprotocolanditsassociatedbodies.IPCC-  workinggoupIworkinggoupIIworkinggroupIII. | | | | |
| **UnitIV** | Socialconnectiontoclimaticchange:ClimatechangeandCarboncredits-CDM-Initiatives in India. Climate justice, Immigration issues. Environmental movements; Theclassiccaseofearthday.Mainclimatechangenegotiationsevolvedoverthepastyears  andhighlightsofsomekeyissuesrelevanttofutureclimatechangeregime. | | | | |
| **UnitV** | Climatic change and Socio-economic implications**:** Economic importance - drought anddesertification-fishingandforestry-changesinmonsoonpattern-industries-foodproductions-healthcare-tourism-transportationandenergyconsideration.Carbontaxand  emissiontrading,Greenfiscalpolicy | | | | |
| **ReferenceandTextbooks**:  Botkin,D.B.andKeller,E.A.(2007),*EnvironmentalScience*:EarthasaLivingPlanet,6thedition,John Wiley&Sons,USA.  Botkin,D.B.andKeller,E.A.(2014).*EnvironmentalScience:EarthasaLivingPlanet*.9thEdition.JohnWiley&Sons.  Burroughs, W.J. (2007). *Climate Change: A Multidisciplinary Approach*. 2ndEdition.Cambridge UniversityPress.  Chasek,P.S.(2004),*TheGlobalEnvironmentintheTwenty-FirstCentury-ProspectsforInternationalCo-operation*,ManasPublications,NewDelhi. | | | | | |

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| ClimateChange:Science,StrategiesandSolutions,Claussen,E.(2001),ArlingtonVA.  ClimateChange:*AMultidisciplinaryApproach*,2ndedition,CambridgeUniversityPress.Dash,S.K.(2007),*ClimateChange-AnIndianPerspective*,CambridgeUniversityPressIndia  PvtLtd.,NewDelhi.  Dodds,F.andMiddleton,T.(2002),*EarthSummit*,aNewDeal,EarthscanPublicationsLtd.,UK.  Enger,E.D.andSmith,B.F.(2006),*EnvironmentalScience*:AStudyofInterrelationships.  11thedition,McGrawHillInc.,USA.  Hardy,John,T.(2003),*Climate Change:Causes,Effects,Solutions*Wiley and Sons,USA.Ranade,P.S.(2008),*ClimateChangeandBiodiversity*:PerspectivesandMitigationStrategies-  ICFAIUniversitypress.  Ranade,P.S.(2008).*ClimateChangeandBiodiversity:PerspectivesandMitigationStrategies*.ICFAIUniversitypress. | |
| **Outcomes** | Oncompletionofthecourse,studentswillbeable   * tounderstandtheenvironmentalissues,energysystems,managementelatedtoclimaticchange * obtainindepthknowledgeofeffectofclimaticchangeonglobalsociety * knowthewayinwhichsocietyworkswiththeeffectsofclimatechangeandclimateadaptation. |

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| **Semester-IV** | | | | | | |
| Core | | | **CoreCourse-15** | **T/P** | **C** | **H/W** |
| **Coursecode:** | |  | **NATURALRESOURCEMANAGEMENT** | **T** | **4** | **4** |
| **Objectives** | * ThecoursedealswithWastetreatmenttechnologiesforresourceandenergy   recoverytodelivervalue-addedproducts. | | | | | |
| **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,Classificationofforestsformanagement,socialforestry,communityforestry.IndianforestpolicyandForestconservation.NationalForestryActionPlan-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 ofIndia, Wildlife conservation in India, Legislation: WLPA – 1972 and 2002 Amendment,developmentandImpactofwildlife,NationalParksandSanctuaries,GO’sandNGO’sin  wildlifeconservation,Eco-tourism. | | | | | |
| **Unit-III** | Energy-Energyrequirement,Impactofenergyutilizationontheenvironment.Conventional sources of energy: Coal, Oil and Natural gas, Thermal power, Firewood,Hydropower, Nuclear power. Non-Conventional Sources of Energy: Solar energy, Windenergy,Ocean/Tidalenergy,Geothermalenergy,Biomassbasedenergy,Dendrothermal  energy,Energyfromurbanwaste,Bagassebasedenergy. | | | | | |
| **Unit-IV** | Thenatureofsoil,characteristicsandvalue.Soilformation,soilprofileandsoilclassification. Soil fertility. Soil conservation and sustainable agriculture: nature of soilerosion; factors affecting soil erosion by water andits control.Alternative agriculture,sustainableagriculture.Landuseandenvironmentalproblemsofsoil.Soilsurveysand  Landuseplanning. | | | | | |
| **Unit-V** | Water-Surface and groundwater, Water management, Rain water harvesting, Water shedmanagement.Aquaculture-Inlandwaterresourcesandtheireconomicpotentialwithrespect to fisheries. Freshwater fish culture, Establishment and management of fish farm.Fishery–asself-employmentavenue(smallscaleindustry),Govt.schemes,Trainingand  incentives. | | | | | |
| **ReferenceandTextbooks**:  SasikumarK(2009).*SolidWasteManagement*.PrenticeHallIndiaLearningPrivateLimited.PatwardhanA.D(2017).*IndustrialWastewaterTreatment*.PHILearningPublication.  RamanathanJagbirSinghA.L(2019).*SolidWasteManagement:PresentandFutureChallenges.*DreamtechPress.  Pachauri,R.K.andSridharan,P.V.(1997),*LookingbacktoThinkAhead:GeenIndia*2047,TheEnergyResearchInstitute,NewDelhi  Dasmann,R. F. (1976),*EnvironmentalConservation*,John Willey and Sons, New York.WasiUllah,Gupta,S.K.andDalal,S.S.(1972),*HydrologicalMeasurementsforWatershed*  *Research*,JugalKishore&Company.  Murty,J.V.S.(2017),*WatershedManagement*,NewAgeInternationalPublishers | | | | | | |

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| Todd,T.KandMays,L.W.(2011),*GroundwaterHydrology*,Wiley.Agarwal,V.C.(2012),*GroundwaterHydrology*,PHILearning.  Klee.G.A.(1991),*Conservationofnaturalresources*,PrenticeHallPubl.Co.,NewJersey.  Owen.O.S.,Chiras,D.D.andReganold.J.P,(1998),*Naturalresourceconservationmanagementforasustainablefuture*,PrenticeHall. | |
| **Outcomes** | * Oncompletionofthecourse,studentscanunderstandthewastegenerationprocess and characteristics of different types of solid wastes and ability to applyrecyclebyresourcerecoverytechnologiesforusefulconversionofspecific   wastetypetoeco-friendlyproducts. |

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