M.Sc.,

ENVIRONMENTAL SCIENCE

SYLLABUS

FROM THE ACADEMIC YEAR

2023 - 2024

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,

CHENNAI – 600 005

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 engagementwith 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 willfacilitate 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

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. ofHours
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		20	**30**

Semester-II

Part	List of Courses	Credits	No. ofHours
	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

Part	List of Courses	Credits	No. ofHours
	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

Part	List of Courses	Credits	No. ofHours
	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

S.No		Courses	Title of the Paper	T/ L/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: Ecological Methods, Environmental Pollution and Environmental Chemistry	L	4	6	50	50	100
4		Elective 1	Environmental Chemistry	T	3	5	25	75	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	L	4	6	50	50	100
9		Elective 3	Environmental Toxicology	T	3	4	25	75	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
					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	L	4	6	50	50	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	-	50	50	100
					26	**30**			

IV-Semester									
18		Core 11	Occupational Health Hazards& Industrial Safety	T	5	6	25	75	100
19		Core 12	Climate Change	T	5	6	25	75	100
20		Project	Project work with Viva Voce	P	7	10	50	50	100
21		Elective 6	Natural Resource Management	T	3	4	25	75	100
		SEC-III	Skill Enhancement Course – III / Professional Competency Skill		2	4	25	75	100
		Extension Activity			1		50	50	100
					23	**30**			
			Total		**91**				

T- Theory; L – Lab; P – Project

Semester-I				
Coursecode: 22MES1C1	**CoreCourse-1**	**T/L/P**	**C**	**H/W**
	Principles of Ecology	**T**	**5**	**7**

Objectives	➢ This course is to make the students to understandthebasicinformationabouttheearth and environment.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,Edgeeffectand EcologicalNiche,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,coastalwaterystemandman-madereservoirs,biologyandecologyofreservoirs.

ReferenceandTextbooks:

EugeneP.Odum(2017).*Ecology*.OxfordandIBHPublishingCo.Pvt.Ltd.

ManuelMolles(2015).*Ecology:ConceptsandApplications*.7th Edition. 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

Semester-I				
Coursecode: 22MES1C2	**CoreCourse-2**	**T/L/P**	**C**	**H/W**
	Environmental Pollution	**T**	**5**	**7**
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, drinkingwater 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 (Endof pipe treatments and its alternatives, online monitoring and treatment of industrial effluents).			
Unit- III	Soil pollution; Definition; broad classification, Sources and broad classification of pollution (*e.g.* urban areas, industrial areas, agriculture and livestock, land-fills, 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 thermical 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.			
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-Gulfof Mexico; e-wastes,ImpactandRemedial Measures.			
ReferenceandTextbooks:	AhluwaliaV.K (2014).*EnvironmentalPollutionandHealth*.TheEnergyandResourcesInstitute,TERI AvinashChauhan(2020)*EnvironmentalPollutionandManagement*.IKInternationalPublishersLtd GuptaO.P(2019).*ElementsofEnvironmentalPollutionControl*.KhannaPublication.			

	MarkBrusseau,IanPepper,CharlesGerba(2019)*EnvironmentalandPollutionScience*,3rdEdition,Academicpress Rao.C.S.(2018).*EnvironmentalPollutionControlEngineering*.3rdEdition.New AgeInternationalPublication. Shafi,S.M(2005)EnvironmentalPollution.AtlanticPublishersandDistributors.
Outcomes	Onsuccessfulcompletionofthecourse, ➢ The students will be able to understand the basic principles and fundamentals ofAir/Soil/Waterpollutantsandtheirimpactonenvironment. Studentswillbeabletogaindetailedknowledgeonlocalandglobalenvironmentalissuesand analyzechemicalprocessesinvolvedindifferentenvironmentalproblems.

Semester-I				
Coursecode: 22MES1C3	**CoreCourse-3**	**T/P**	**C**	**H/W**
	Environmental Chemistry	**T**	**3**	**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.
Referenceand Textbooks:	BalramPani,(2007)TextBookofEnvironmentalChemistry,I.K.InternationalPublishingHousePVT.Lt d. DaraS,MishraD.D(2006).ATextbookofEnvironmentalChemistryandPollutionControl.S.ChandPubl cation. GaryW.VanLoon,StephenJ.Duffy(2017).EnvironmentalChemistry:Aglobalperspective. 4thEdition.OUPOxford. GirardJ.E.(2015)PrinciplesofEnvironmentalChemistry. JulianE.Andrews,PeterBrimblecombe,TimD.Jickells,PeterS.Liss,BrianReid(2013).AnIntroduction toEnvironmentalChemistry.Wiley-BlackwellPublication. Rao,C.S.(2018)EnvironmentalPollutionControlEngineering,3rdEdition,NewAgeInternational(P)L tdPublishers.
Outcomes	Onsuccessfulcompletionofthecourse,thestudents ➢ Haveknowledgeofbasictheoriesandproblemsof Environmentalchemistry ➢ Describeimportantchemicalreactionsandcyclicprocessesofchemicalspeciesintheatmosphere,hydrosphereandinlithosphere ➢ Demonstrateknowledgeofchemicalprinciplesofvariousfundamentalenvironmentalphenomena ➢ Applybasicchemicalconceptsinunderstandingthebehaviorofpollutants ➢ Analyzechemicalprocessesinvolvedinair,waterandsoilenvironmentalproblems Knowthedifferenttypesoftoxicandhazardoussubstancesandanalyzetheir toxicologicalinformation

Semester-I				
Coursecode: 22MES1P1	**CoreCourse-3**	**T/L/P**	**C**	**H/W**
	Lab-I: Ecological Methods, Environmental Pollution and Environmental Chemistry	**L**	**4**	**6**

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.

Semester-I				
Coursecode: 22MES1E1	DSE-I A	**T/L/P**	**C**	**H/W**
	DISASTERMANAGEMENT	**T**	**3**	**5**

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.
Referenceand Textbooks:	1. DavidR.Godschalk,NaturalHazardMitigation:RecastingDisasterPolicyandPlanning(Editor),Timo thy Beatley, PhillipBerke, David J. Bowe, Edward J. Kaiser Charles C. Bohl,R. Matthew Goebel ,I slandpress:(January1999),ISBN1559636025 2. NaturalDisasterManagement,TudorRose,6FriarLaneLeicesterLE15RAUnitedkingdom.JeffGroman (2002) 3. The Atlas of Natural Disasters by (Author) Publisher: Friedman/Fairfa Publishing;(March2002). 4. Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U. K. Sharma,R.K.&Sharma,G.(2005)(ed)NaturalDisaster,APHPublishingCorporation, NewDelhi 5. Carter,NW.*DisasterManagement*:AdisasterManager'sHandbook,AsianDevelopment Bank, Manila. (1992).

	6. Gautam Ashutosh1994.*Earthquake: A Natural Disaster*.Ashok Publishing House.NewDelhi. Singh R.B. 2006 *Natural Hazards and Disaster Management*; Vulnerability and Mitigation. RawatPublications. 7. JochenZschau,AndreasN.Kuppers(2003). *Early warning Systems for Natural Disaster Reduction*. Springer-Verlag, Berlin Heidelberg.
Outcomes	Onthesuccessfulcompletionofthecourse,studentswillbeableto ➢ UnderstandtheEmergency/DisasterManagementCycle. ➢ Develop a basic understanding of Prevention, Mitigation, Preparedness, Response and Recovery

Semester-I				
Coursecode: 22MES1E2	DSE-IB	**T/P**	**C**	**H/W**
	ENVIRONMENTALLAWSANDPOLICIES	**T**	**3**	**5**
Objectives	➢ Toimpartknowledgeaboutenvironmentallaws,regulationsandpoliciesofIndia andinternationalenvironmentallaws.			
Unit-I	Internationalenvironmentalpolicy– environmentalproblemsandtheirimpactoninternationalsystem,theinstrumentsofinternationale nvironmentalpolicy-Transnationalenvironmentalpolicies–theIndusriverbasin,theGanga–Brahmaputra riverbasinsystem			
Unit-II	Environmentalplanning-conceptsandapproachesandstrategicof environmental planningandmanagement.InternationalEnvironmentallaws.NecessityforInternational EnvironmentalCourt.UnitedNationsEnvironmentProgramme[UNEP]roleoninternationalenvi ronmentlaws.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,thenationalenvironmentappellateautho rityactof1997,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			
Referencea ndTextbook s:	GurudeepSingh(2005)*EnvironmentallawinIndia*–McMillan,NewDelhi. Shyam Diwan and Armin Rosencrany, 2001, *Environmental law and policy in India*, Oxford University Press, New Delhi. *Pollution Control Legislations*, Vol.I and I 1999, Tamilnadu Pollution Control Board, Chennai. NathB.,Hens,L.,Compton,PandD.Devuyst(1998),*EnvironmentalManagementinPractice*,Vol I,Routledge,LondonandNewYork. TheISO14000Handbook:JosephCascio.ISO14004– *Environmental management systems*: *General guidelines on principles*, systems and supporting teaching ues(ISO14004:1996(E).ISO14001:*Environmentalmanagementsystems*:Specificationwithgui danceforuse (ISO14001:1996b(E)) .(International organization for standardization– Switzerland).			

Outcomes	Onthesuccessfulcompletionofthecourse,studentswillbeableto ➢ Understandenvironmentallegislationandpoliciesofnationalandinternationalregime. Haveaninsightintomajoractsandrulesapplicableforpollutioncontrolandnaturalresou rceconservation. ➢ developtheskillsneededforinterpretinglaws,policiesandjudicialdecisionsaboutthee nvironment. ➢ Knowregulationsapplicabletoindustriesandotherorganizationswithsignificantenvir onmentalaspects. ➢ Applythelegislationconceptsforsolvingthelocalenvironmentalproblems. ➢ GetknowledgeofthelegalsystemoperatinginIndia. ➢ Beinapositiontopreparecompliancereportsforgettingenvironmentalclearance Preparetheenvironmentalmanagementsystemforanorganization.

Semester-II				
Coursecode: 22MES2C1	**CoreCourse-4**	**T/L/P**	**C**	**H/W**
	Environmental Microbiology	**T**	**5**	**6**
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. Microbia 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.(20 09),*EnvironmentalMicrobiology*,2nd edition, Wiley-Blackwell. Mohapatra,P.K.(2008),*TextbookofEnvironmentalMicrobiology*,I.K.International(P)Ltd.			

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

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Semester-II				
Coursecode: 22MES2C2	**CoreCourse5**	**T/P**	**C**	**H/W**
	Environmental Biotechnology	**T**	**5**	**6**
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,Surfactants andmicrobial treatment of oil pollution. Microbial Systems for Heavy Me 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,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 andsalientfeaturesofBiosafteyguidelinesandregulations-RightsIntellectualproperty rights-TRIP-GATT-Plantvarietyprotection.
Reference and Textbooks:	1. ChatterjiA.K(2011).IntroductiontoEnvironmentalBiotechnology.PrenticeHallIndia LearningPrivate Limited. 2. Evano,G.H.andFurlong,J.C.(2004),EnvironmentalBiotechnology– TheoryandApplication,JohnWiley andSons,USA. 3. GarethM.Evans,JudithC.Furlong(2012).Environmental Biotechnology– TheoryandApplication.2ndEdition. Wiley India pvt Ltd. 4. Jjemba,P.K.(2004),EnvironmentalMicrobiology– TheoryandApplication,SciencePub. 5. Inc.,USA. 6. Olguin, C.J.,Sanchez,G. ,Hernandez.E.(2000), Environmental Biotechnology and Cleaner Bioprocesses, Taylor & Francis. 7. Pepper,I.L. and Gerba,C.P.(2005),EnvironmentalMicrobiology-LaboratoryManual,Elsevier,USA. Ratledge,C. and Kristiansen,B.(2003), Basic Biotechnology, 2nd edition, Cambridge University Press. 8. ViswanathBuddolla(2017).Environmental Biotechnology: Basic Concepts and Applications. Alpha Science International Ltd
Outcomes	On successful completion of the course, the students ➢ WillobtaintheknowledgeofExistingandemergingbiotechnologicalapproachesinrem ediation of pollution and environmental management. ➢ Implement various practical approaches to address environmental issues relevantto environmental biotechnology.

Semester-II				
Coursecode: 22MES2C3	**Elective 3**	**T/P**	**C**	**H/W**
	Environmental Toxicology	**T**	**3**	**4**
Objectives	This course is designed to offer an outline on toxicology, including an introduction of The major groups of pollutants, their fate in the environment, their disposition inorganism and their mechanisms of toxicity. The toxicity assessment of pollutant sinbiological and Environmental systems is also included.			
Unit-I	**IntroductiontoToxicologyandToxicants:**DefinitionofToxicology,ToxicityandToxicants. Classification of toxic agents – natural toxins (Animal, Plant and microbialtoxins) and Anthropogenic toxicants (Chemical toxins).Classes of environmental toxicants; Inorganicions (Metals-Hg,Anions-NO_3), Organic contaminants(Hydrocarbons and PCBs)– Organochlorine insecticides (DDTandAldrin), Organophosphorus insecticides (Parathion, Carb omates and Pyrethroids). Detergents, Pharmaceuticals and Personal Care Products.			
Unit-II	**Entry, Distribution and Mode of Action:** Routes of Entry –Inhalation, Absorption, Ingestion, Injection. Biodistribution, Biomagnification and Biotransformation.Types ofToxicity–Acute,SubacuteandChronic.EffectsofToxicants-Short TermandLongterm.DoseResponseRelationship- LC_{50} ,LD_{50} ,EC_{50} .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 Toxicant and Effects -Pulmonary (Irritation, Cellular Damage, Oedema and Lung Cancer) Hepatotoxicants andEffects– FattyLiver(Steatosis),LiverNecrosis,Cirrhosis,Cholestasis,Virallike Hepatitis.NephrotoxicantsandtheirEffects.			
Unit IV	**SystemicToxicologyII:**NeurotoxicantsandEffects(Neuronopathy,Axonopathy).Effect ofToxicants on Reproductive and Cardiovascular System.Endocrine DisruptingChemicalsandtheirToxicity.Immunotoxicants–MechanismsofImmuno-toxicity,Immuno-suppression,DirectandindirectEffectsofToxicants,ImmuneMediated Diseases,(HypersensitivityandAllergy)			
UnitV	**Ecotoxicogenomics, Toxicity Testing and Risk Assessment of Toxins:** Introduction to Toxic cogenomics, Toxic Proteonomics, and Metabolonomics – Modification of DNA, RNA and Preotein Metabolism by Toxicants, Gene Expression Changes by Toxicants – Role of ecotoxicogenomics for Environmental Monitoring			
Reference and Text books:	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.SiblyandD.B.Peakall,(2006),*Priciples of Ecotoxicology*, Third Edition, CRC Press (Taylor& Francis Group). DanielA.Vallero,(2005),*EnvironmentalContaminants-Assessment and Control*, Academic Press. DavidJ. Hojjman, BarnettA. Rattner,G. AllenBurton, Jr., and John Cairns, Jr.,(2000), *Handbook of Ecotoxicology*, CRC Press (Taylor & Francis Group).			

	EnvironmentalToxicants-HumanExposureandTheirHealthEffects,MortonLippmann,(2000),John Wiley and SonsPublication. KatalinGruiz,TamsMeggyesandEvaFenyvesi,(2014),*EnvironmentalToxicology*-EngineeringToolsforEnvironmentalRiskManagement,CRCPress(Taylor&FrancisGroup). LU'sBasicToxicology(Fundamentals,TargetOrgansandRiskAssessment),SixthEdition,Samkacew andByung-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*.3rd Edition, AcademiaPress. RobertBurke,(2000),*HazardousMaterialsChemistryforEmergencyResponders*,LewisPublishers. Schmidt, T. M. and Schaechter, M (2012). *Topics in Ecological and Environmental Microbiology*. 3rdEdition, AcademiaPress. Wayne.G.Landis,MingHoYu,3rdEd.(2002)*IntroductiontoEnvironmentalToxicology*,LewisPublish ers,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-6**	**T/L/P**	**C**	**H/W**
	Lab-II: Environmental Microbiology & Environmental Biotechnology	**L**	**4**	**6**

Objectives

- Thecourseprovidespracticalguidelinesonconductingexperimentsacrossthe entirespectrumofenvironmentaltoxicology,biotechnologyandmicrobiology.

1. GoodMicrobiologylaboratorypractices:Laboratorysafety(DosandDon'ts),
2. Topreparebasicliquid(Nutrientbroth)andbasicsolidmedia(NutrientAgarandPotatoDextroseAgar)for cultivationofbacteriaandfungi.
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 characteristic ofbacteria and fungi a. Simple staining b. Gram Staining c. Fungal staining (Lacto-phen 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:

1. AlexanderN.GlazerHiroshiNikaido(1995)*MicrobialBiotechnology*,WHFreemanandCompany,NY, USA.
2. BernaralR.GlickandJackJ.Pastemak(1994)*MolecularBiotechnology:PrinciplesandApplicationsofR ecombinantDNA*,ASMPress.Washington,DCUSA.
3. Brown,T.A.(1995)Genecloning-*Aintroduction*-Chapman&Hall,London.
4. David Woolley,Adam Woolley (2013).*AGuidetoPracticalToxicology:Evaluation,Prediction,andRisk*.2nd Edition.Taylo randFrancisPublication.
5. Dr. Ratna Trivedi(2016). *Practical Manual of Environmental, Microbiology andBiotechnology*.Academicpress.
6. GlazerandNikaido(1995)MicrobialBiotechnology.WHFreeman&Co.,NewYork.
7. JayantaKumarPatra,GitishreeDas,SwagatKumarDas,HrudayanathThatoi(2020).A*PracticalGuidetoEnv ronmentalBiotechnology(LearningMaterialsinBiosciences)*.Springerpublication.

Outcomes

Onthesuccessfulcompletionofthecourse,studentswillbeableto

- Explaintheroleofmicrobesindegradationofenvironmentalpollutants
- Acquireskillsinmanipulatingthemicrobesforbiodegradationofpollutants
- Developprocessesforwastebioconversiontovalue-added products.
- Becomean entrepreneur/researcher in the areas of environmental biotechnology.

Semester-II				
Coursecode: 22MES2E1	DSEE-IIA	**T/L/P**	**C**	**H/W**
	BIOREMEDIATION	**T**	**3**	**4**

Objectives	As an introduction course, it includesanoverviewofthebioremediationprocess;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,biotechniquesforair pollutionabatementand odour control-bioscrubbers,biobeds,biotricklingfilters,biodeterioration.
Unit-II	Bioremediationofinorganicpollutants-Heavymetalsandradionuclides-microbialinteraction with metallic elements - molecular mechanism of metal resistance, biosorptionandbiotransformationofmetalsandradionuclides,biomining,Nitrate-Nitrificationand denitrification-Phosphate- Biological Phosphate removal, Phytoremediation.
Unit III	Waste utilization and management, Bioplastics, Biosensor technology, Biofuels, Vermitechnology,SCP,Biofertilizer.
Unit IV	Molecular techniques in bioremediation–pathway construction–Biochemicalbackground,Operonderegulation,Vectors,Hybridpathwaysandenzymes,Noncatabolic genesforcatabolicpathwayconstructuion,Rationalenzymeredesign.
Unit V	GEM–degradativeplasmids,promotingGEMsurvival–implicationsforbioremediation, preventing GEM survival – suicide contaminant systems – GMOs in foodproduction–transgeniccrops–Biosafety–Bioethics–Patents–Patentlawsand regulation.

Reference and Textbooks:

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

Semester-II				
Coursecode: 22MES2E2	DSE-IIB	**T/L/P**	**C**	**H/W**
	BIODIVERSITY AND CONSERVATION	**T**	**3**	**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 –Specie 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,Ecocentrismand Religions;IntellectualValue;EconomicsofEcosystem,GreenRevolution,FoodPlants,medicinaandornamental 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 - traditionalsocieties-Governmentactionlocallegislation-nationallaws-NationalBiodiversityActandNationalBiodiversityAuthority.Internationalapproachestoconservationandsustainabledevelopment-Ongoingproblems-possibleresponses-roleofconservationbiologists.
Reference and Text books: .	1. Chaudhuri,A.B.andD.D.Sarkar(2003),MegadiversityConservation,flora,FaunaandMedicinalPlant sofIndia'shotspots,DayaPublishingHouse,Delhi. 2. Singh,M.P.,B.S.SinghandSomaS.Dey(2004),ConservationofBiodiversityandNatural Resources.Da yaPublishingHouse,Delhi. 3. DadhichL.K.andA.P.Sharma(2002),Biodiversity–StrategiesforConservation,APHPublishingCorporation,NewDelhi. 4. Khan,T.IandDhariNAlAjmi(1999),GlobalBiodiversity– Conservation Measure, Pointer Publishers, Jaipur. 5. Krishnamurthy,K.V(2003),AnAdvancedTextbookonBiodiversity–PrinciplesandPractice,OxfordandIBHPublishing,NewDelhi. 6. T.B.1:Krishnamurthy,KV.,2003,AnadvancedTextbookonbiodiversity,OxfordandIBHBook.Co.,Ne wDelhi. 7. T.B.2:Hall,BK.andHallgr imsson,B.,2014.Evolution,5thEdition,JohnesandBartlettIndiaPvt.Ltd.Ne w Delhi. 8. Ridley,M.,,2004,Evolution,3rdEdition,BlackwellScienceLtdaBlackwellPublishingcompany,USA
Outcomes	Protected and restored marine and estuarine ecosystems. Controlled invasive species,Mitigateddrylandsalinity,Promotedecologicallysustainablegrazing,Minimized imp actsofclimatechangeonbiodiversity,Maintainedandrecordindigenouspeoples' Ethnobiologicalknowledge,Improvedscientificknowledgeandaccesstoinformation.

<table>
<tr><th colspan="5">Semester – II</th></tr>
<tr><td rowspan="2">Course code:
22MES2S1</td><td>SEC – I</td><td>T/L/P</td><td>C</td><td>H/W</td></tr>
<tr><td>MICROBIAL QUALITY ANALYSIS OF FOOD, AIR AND WATER</td><td>T</td><td>2</td><td>4</td></tr>
<tr><td>Objectives</td><td colspan="4">• .To understand nucleic acid structure and functions
• To analyse the importance and interactions between molecules
• To interpret the processes of life in molecular terms</td></tr>
<tr><td>Unit-I</td><td colspan="4">Good laboratory practices - Good laboratory practices, Good microbiological practices Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration</td></tr>
<tr><td>Unit-II</td><td colspan="4">Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products Molecular methods - Nucleic acid probes,
PCR based detection, biosensors.</td></tr>
<tr><td>Unit- III</td><td colspan="4">Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk
at milk collection centres (COB, 10 min Resazurin assay)</td></tr>
<tr><td>Unit- IV</td><td colspan="4">Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens; Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and
fungi, Identification characteristics; Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration</td></tr>
<tr><td>Unit-V</td><td colspan="4">Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water</td></tr>
<tr><td colspan="5">Reference and Textbooks:
1. WatsonJD,BakerTA,BellSP,GannA,LevineMandLosickR.(2014)MolecularBiologyofthe Gene,6thedition,ColdSpringHarbourLab.Press,PearsonPublication.
2. Alberts B and Jhonson AD.(2014)Molecular BiologyoftheCell,6thedition, Garland Science.
3. KrebsJ,GoldsteinE,KilpatrickS.(2013)Lewin’sEssentialGenes,3rdEd.,JonesandBartletLearning.
4. GardnerEJ,SimmonsMJ,SnustadDP.(2008)PrinciplesofGenetics.8thEd.Wiley-India.
5. Brown TA. (2007) Genomes-3. Garland Science Publishers.
6. Rastogi SC. (2012) Cell and Molecular Biology. New age international publication.</td></tr>
<tr><td>Outcomes</td><td colspan="4">Upon successful completion of the course, the student can
Understand biologically important molecules’ structure, function and interaction</td></tr>
</table>

Semester-III				
Coursecode: 22MES3C1	**CoreCourse-7**	**T/P**	**C**	**H/W**
	BIOSTATISTICS AND RESEARCH METHODOLOGY	**T**	**5**	**6**
Objectives	Toimpartunderstandingontheconceptsofbiostatisticsandtoimprovethe Computingknowledgeofthestatisticalmethodsrelatedtoenvironment			
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.			
Reference and Text books:	1. ArvindShendeandVijayUpagade(2010).*ResearchMethodology*.S.ChandPublications. Bliss,G.I.(1970),*StatisticsinBiology*.McGrawHillBookCompany,Vol.IandII.NewDelhi. ByronSGottfried(1996),*ProgrammingwithC*,HillPublishingCo,NewDelhi.GuptaS.P.(20 14).*StatisticalMethods*.SultanChand&SonsPublications. 2. Gupta,S.P.(1996)*StatisticalMethods*,SultanChand&SonsPublications,NewDelhi.Haynes,R(1982) 3. *EnvironmentalScienceMethods*,Chapman&Hall,London. Khan,I.AandKanum,A.,(1994)*FundamentalsofBio-Statistics*,UkaazPublication,Hyderabad. 4. Kothari,C.R(1996),*QuantitativeTechniques*,VikasPublishingHousingPvtLtd,Hydera			

	bad. 5. Kothari,C.R.,(1989),*ResearchMethodology–MethodsandTechniques*.WileyEastern,NewDelhi. Miller,J., (1989), *Statistics for Advanced Level*,Cambridge UniversityPress.RastogiV.B(2009).*FundamentalsofStatistics*.ANEBooks. 6. Snedcor,G.W.andCochran,W.G.(1982),*StatisticalMethods*,AcademicPress.Vittal,R. R.(1986)*BusinessMathematicsandStatistics*,MurghamPublications. 7. Wardlaw,A.C.(1985),*PracticalStatisticsforExperimentalBiologists.*WileyChichester . 8. Sharma,B.A.V., RavindraPrasad,D. and Satyanarayana,P (1989)*Research Methods inSocialSciences*.SterlingPublishersPvt.Ltd. 9. WayneW.Daniel,ChadL. Cross(2014).*Biostatistics:BasicConceptsandMethodologyfortheHealthSciences*.10th Edition.WileyPublication.
Outcomes	Onsuccessfulcompletionofthecourse,thestudents ➢ Knowthetypesofresearchandscientificdatabases,reportwritingandplagiarism. ➢ Chosetheresearchthattheywanttocarryout. ➢ Identifyanddesigntheirresearchproblems. ➢ Understandtheprinciplesofresearchmethodsandinstrumentsrequiredfortheir researchexperiments. Applytheirknowledgeoninstrumentationforenvironmentalanalysis,andfield worksanddatacollection.

Semester-III				
Coursecode: 22MES3C2	**Core Course-8**	**T/P**	**C**	**H/W**
	Remote Sensing &GIS	**T**	**5**	**6**
Objectives	Toteachtheprinciplesandapplicationsofspatialinformationtechnologiesvi zRS,GPSandGISabo utthedistributionofresources.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 an microwaveimageinterpretation.Applicationsofdifferenttypesofimagesinearth Sciences,Enviro nmentalSciences,Archeology,Marinestudies,Forestry,Soils,Hazard managementetc.			
Unit-II	Conceptsandfoundationsofremotesensing-Historyofremotesensing-Electro-magneticenergy– Propertiesandinteractionwiththeearth.Atmosphericwindows.Black,whiteandgreybodies,sour cesofEMR.Imageinterpretations.Aerialphoto-classificationbasedonattitudeofcameralens,distortionscausedduetoflightirregularities,overlap s,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.			
Reference and Text books:	1. Barrett,E.CandCurtis,L.F(1982).IntroductiontoEnvironmentalRemoteSensing,Basud ebBhatta(2008).*RemoteSensingandGIS*.OUPIndia. 2. Danson,F.MandPlummer,S.E(1995),AdvancesinEnvironmentalRemoteSensing,Spa ceRemoteSensing Systems–AnIntroduction,Chen,H.S(1985). 3. Fischer,M.MandNijkamp,P(1993).GeographicInformationSystems,SpatialModelinga ndPolicyEva luation,Springer–Verlag. 4. Jensen(2013).*RemoteSensingoftheEnvironment:AnEarthResourcePerspective*.Pearso nEducationIn dia. 5. KramerJ.Herbert(2002),Observation of Earth and its Environment– Survey of Missions and Sensors Springer- Verlag. 6. Fundamentals of Remote Sensing, George Joseph (2003) Universities Press (India) Ltd. Hyderguda,Hyderabad 7. Martin Wegmann, Benjamin Leutner and Stefan Dech (2016) . *Remote Sensing and*			

	GIS for Ecologists: Using Open Source Software (Data in the Wild). Pelagic Publication. 8. Muralikrishna,I.V(1995).Remote Sensing and GIS for Environmental Planning, Tata-McGraw Hill. 9. Roody,G.M and Curran,P.J (1994). Environmental Remote Sensing from Regional and Global Scales, 10. Singh,R.B (1992), Environmental Monitoring: Applications of Remote Sensing and GIS, Geocartho International Centre, HonkHong. 11. William K Pratt (2001),Digital Image Processing, John Wiley & 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, Image enhancement and interpretation methods ➢ UseGPSforvariousenvironmentalapplications. ➢ Able to apply the to olso fremotesensingandGISforenvironmentaldisastermanagemen tandconservation

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Semester-III				
Coursecode: 22MES3C3	**CoreCourse-9**	**T/L/P**	**C**	**H/W**
	ENVIRONMENTALIMPACTASSESSMENT	**T**	**5**	**6**
Objectives	This course tells about the need ofindustry and society to predict and includeenvironmentalconcernsandriskswhiledevelopingprojects.Thecoursealsodescribesthe moderntoolsandtechniquestoevaluatetheenvironmentalimpactsandoutlines 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,ImpactPredict on-MitigationAspects-AssessmentofAlternatives,PublicHearing,DecisionMaking-TechniquesforAssessmentofImpactsonPhysicalResources,Ecological Resources,HumanuseValuesandQualityofLifeValues.			
Unit-II	**EIAMethodologies:**ChecklistMethodologies-AdhocMethod-NetworkMethods-MatrixMethods-MapOverlayMethod-PreparingEIA-InteractingParametersInteraction-EnvironmentandDevelopmentActivities-ComparativeStudiesonMethodology.PredictionandAssessmentofImpactsonBiological,SurfaceWaters, Ground Water,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 and Resettlement Policy; EvolutionofEnvironmentalLegislationinIndia,LegalProvisionsfor Environmental Protection; Various Acts, Rules and Regulations. Notifications IssuedunderVarious Acts and Rules. Environmental Standards, Criteria for Standards Setting.PublicLiabilityInsuranceActandLegalAspectsRelatingtoHazardousandToxic Substances.RoleofNationalGreenTtibunals.			
UnitIV	**EnvironmentalEthics:**ImplementationofInternationalEmissionTrading,ResourceConsumptonPatternsandtheneedforEquitableUtilization-Equity-DisparityintheNorthern and Southern Countries, Urban and Rural Equity Issues- The need for GeneralEquity,Preserving Resources for Future Generation- TheRights of Animals-Preparationof Environmenta 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.			

Reference and Text books:	1. BregmamJ.I(1999),EnvironmentalImpactStatements,LewisPublishers,London. 2. CharlesH.Eccleston(2011).*EnvironmentalImpactAssessment:AGuidetoBestProfessionalPractices*. CRCPress. 3. EcclestonC.H,(2000),EffectiveEnvironmentalAssessment,LewisPublishers,London. 4. EranchBharucha,(2005),TextbookofEnvironmentalStudies,UniversityGrantsCommission 5. JaneHolderandMariaLee,(2007),EnvironmentalProduction,LawandPolicies,Second Ediction 6. JohnGlasson(2005),IntroductiontoEnvironmentalImpactAssessment,NaturalandBuilt Environment Series.Routledge,TaylorandFrancis. 7. Khandeshwar S.R, Raman N.S,Gajbhiye A.R(2019). *Environmental Impact Assessment*. DreamtechPress**.** **8.** LarryW.Canter(2013),EnvironmentalImpactAssessment,JohnWileyandSons.RamachandranS(201 9).*EnvironmentalImpactAssessment*.AirwalkPublications. **9.** SingletonR,CastlePandSortD(1999),EnvironmentalAssessment,ThomasTelfordPublishingLondon. 10. SureshK.Dhameja,(2005),EnvironmentalScienceandEngineering,PublishedbySanjeev KumarKatar ia,Delhi.
Outcomes	Onsuccessfulcompletionofthecourse,studentscan ➢ UnderstandthescopeofEIA ➢ LearnttypesandmethodsofEIAprocess ➢ Developedfactorscorrelationskills ➢ IdentifytheroleofEIAinsustainableenvironmentmanagement ➢ ImprovedtheknowledgeaboutEIAsignificanceandmagnitude ➢ Involvedeconometricvaluesonlevelofimpact ➢ Developedinteractionmatrixbetweenvariables Learntnationalandinternationalprotocolson EI

Semester-III				
Coursecode: 22MES3C4	**Core Course-10**	**T/L /P**	**C**	**H/W**
	Lab-III: Biostatistics &Research methodology, Remote Sensing &GIS and EIA	**L**	**4**	**6**

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 mappin technology,conceptsofmapsandallrelevantterminologywhicharenecessaryforabeginnertodevelophsskillsin thisnewand upcoming technology.

Semester-III				
Coursecode: 22MES3E1	**DSE-IIIA**	**T/L/P**	**C**	**H/W**
	Instrumentation &Analytical Techniques	**T**	**3**	**3**
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 Principlesandtechniquesofnucleicacidhybridizationand Cotcurves,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,Molecularmarkers RFLP,AFLP,RAPD,Sequencingofproteinsandnucleic acids,southern,northern,westernblottingtechniques,PCR-polymerasechainreaction.			
Reference and Text books:	1. Uppadahay,A.,Uppadahay,N.andandNath,N.(2016),BiophysicalChemistry,Principlesand Techniques,HimalayaPub.House,NewDelhi. 2. Sawyer,C.N.,McCarty,P.L.andParkin,G.F.(2002),ChemistryforEnvironmentalEngineeringand Science,McGraw-HillEducation 3. Rupa,H.H.andKrist,H.(1998),LaboratoryManualfortheExaminationofWater,Wastewaterand soil,VC HPublication,NewYork. 4. Sharma,B.K.(2001),InstrumentalMethodsofChemicalAnalysis,GoelPublishingHouse,Meerut,India .			
Outcomes	Thestudentsonexposuretothiscoursewillbeableto ➢ Understandthebasicsandrequirementofenvironmentalanalysis ➢ Understandtheenvironmentalqualityparameterstobemonitoredanddetermined ➢ Knowtheroleofsamplepreparationinenvironmentalanalysis ➢ Understandtheinstrumentaltechniquesandmethodsofanalysis			

Semester-III				
Coursecode: 22MES3E2	**DSE-IIIB**	**T/L/P**	**C**	**H/W**
	ENVIRONMENTAL EDUCATION	**T**	**3**	**3**
Objectives	➢ Thecourse focusesonIntroductiontobasicprinciplesof environmentalhealthand safety practices and creating awareness of public and occupational health andsafet requirements associated with the environment. The purpose ofthis cours 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 organizatior 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-forma 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-Population and environment.
Reference and Text books:	1. Canter,E.W.(1977):*EnvironmentalImpactAssessment*.McGrawHillCo.,NewYorkFed ron,E.(1980):*ManandNature*,ProgressPublishers,Moscow 2. Kormondy,E.(1991):*ConceptofEcology*,PrenticeHallofIndia,NewDelhi.Odem,E.P.(1 9 75):*Ecology*,OxfordandIBHPublishingCo.,NewDelhi. 3. Purdom,P.W.&Anderson:*EnvironmentalScience*,CharlesE.MerrilPublishingCo., 4. Saxena,A.B.(1996): *Education for the Environmental Concerns*, Implications and Practices, Radha Publication, NewDelhi. 5. Sharma,P.D.(1993):*EnvironmentalBiology*,Rastogi&Co.,Meerut.
Outcomes	Onsuccessfulcompletionofthecourse,thestudentsget ➢ Knowledgeintheconceptsandscope,basicrequirementsforhealthyenvironment,envi ronmentalquality,humanexposureandhealthimpact. ➢ Knowledge of the Industrial pollution and chemical safety in public exposurefrom industrial sources, Hazards by industry major chemical contaminants atworkplace.Industrialenvironmentalaccidents. ➢ KnowledgeaboutEnvironmentalDiseasepresentstudyinFluorosisandAllergies;Epid emiologicalissues. ➢ Knowledge of understand course will equip student with basic knowledge onsafetyissuerelatedwithexplosion,pollutantreleaseinwaterandair,and ➢ to implementmeasureduringoutbreakoffluepidemicatworkplace.

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Semester-III				
Course code: 22MES3S1	**SEC –II**	**T/L/P**	**C**	**H/W**
	TERM PAPER AND SEMINAR (MINI PROJECT) PRESENTATION	**T**	**2**	**3**
Objectives	• To analyze, construct /create, and evaluate information presented in technical and/or scientific journals.			
Assignment I	Usage of internet and offline sources for information collection; Scientific journals – SCI, Q index based classifications; Impact factor and h-index;			
Assignment II	Choose field of research interest. Analyze, evaluate and prepare report of 10 best journals suitable for publication of his/her research			
Assignment III	Read, analyze, evaluate and prepare report based on 10 best journals suitable for publication of his/her research according to university thesis format			
Assignment IV	Prepare a presentation based on his/her research work published in 5 best research journals.			
Assignment V	Deliver 10 minute presentation of mini project research work including brief introduction to the article, the methodology used, findings and a conclusion.			
Outcomes	The student completed this course can expect to • Be an active and engaged participant by analyzing, constructing/creating, and evaluating information presented in technical and/or scientific journals. • Practice critical evaluation of other students' work.			

Semester-IV				
Coursecode: 22MES4C1	**CoreCourse-11**	**T/L/P**	**C**	**H/W**
	OCCUPATIONALHEALTHHAZARDS ANDINDUSTRIALSAFETY	**T**	**5**	**6**
Objectives	Thestudentsonexposuretothiscoursewillunderstandthedifferenttypesofhazardsdisasterspossibleintheindustries.Focushasbeenmadeonthesafetyandmanagemepracticedinindustriesbyhighlightingcertaincasestudies.			
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,H_2S) –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.			
Reference and Text books:	DellaD.E.,andGiustina,(1996),SafetyandEnvironmentalManagement,VanNostrandReinhold InternationalThomsonPublishingInc. GoetschD.L.,(1999),OccupationalSafetyandHealthforTechnologists,EngineersandManagers, Prent ceHall. 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.,			

	NewYork.Walsh,WandRussell,L,(1984),ABCofIndustrialSafety,PitmaPublishingUnited Kingdom.
Outcomes	Oncompletionofthecourse,students ➢ Applyknowledgeofscienceinthemanagementof Industrialsafetyandhealth. ➢ Identifyindustrialsafetyandhealthproblems. ➢ Understandprofessionalandethicalresponsibilityinsafetymanagementofindustries. ➢ Learningtodealwiththecontemporaryissuessurroundingoccupationalsafetyandhealth. ➢ Learningtechniquesandcontrolofhazardoussubstances. ➢ Recognizetheneedforaprofessionaldevelopmentinthisfield. ➢ Solvetheproblemsrelatedwithindustrialsafety. ➢ Understandtheimpactofoccupationalsafetyandhealth

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Semester-IV				
Coursecode: 22MES4C2	**CoreCourse-12**	**T/P**	**C**	**H/W**
	CLIMATECHANGE	**T**	**5**	**6**
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.			
UnitI V	Socialconnectiontoclimaticchange:ClimatechangeandCarboncredits-CDM-Initiatives in India. Climate justice, Immigration issues. Environmental movements; Theclassiccaseofearthday.Mainclimatechangenegotiationsevolvedoverthepastyears andhighlightsofsomekeyissuesrelevanttofutureclimatechangeregime.			
Unit V	Climatic change and Socio-economic implications**:** Economic importance - drought anddesertification-fishingandforestry-changesinmonsoonpattern-industries-foodproductions-healthcare-tourism-transportationandenergyconsideration.Carbontaxand emissiontrading,Greenfiscalpolicy			
Reference and Text books:	1. Botkin,D.B.andKeller,E.A.(2007),*EnvironmentalScience*:EarthasaLivingPlanet,6thedition,John Wiley&Sons,USA. 2. Botkin,D.B.andKeller,A.(2014).*EnvironmentalScience:EarthasaLivingPlanet*.9th Edition.JohnWiley&Sons. 3. Burroughs, W.J. (2007). *Climate Change: A Multidisciplinary Approach*. 2nd Edition.Cambridge UniversityPress. 4. Chasek,P.S.(2004),*The Global Environment in the Twenty First Century- Prospects for International Co operation* ,Manas Publications, NewDelhi. 5. ClimateChange:Science,StrategiesandSolutions,Claussen,E.(2001), ArlingtonVA.			

	6. ClimateChange:*AMultidisciplinaryApproach*,2ndedition,CambridgeUniversityPress. Dash,S.K.(20 07),*ClimateChange* 7. *AnIndianPerspective*,CambridgeUniversityPressIndia PvtLtd.,NewDelhi. 8. Dodds,F.andMiddleton,T.(2002),*EarthSummit*,aNewDeal,EarthscanPublicationsLtd. ,UK. 9. Enger,E.D.andSmith,B.F.(2006),*EnvironmentalScience*:AStudyofInterrelationships. 11thedition,McGrawHillInc.,USA. 10. Hardy,John,T.(2003),*Climate Change:Causes,Effects,Solutions*Wiley and Sons, USA 11. Ranade,P.S.(2008),*ClimateChangeandBiodiversity*:PerspectivesandMitigationStrate gies- ICFAIUniversitypress. 12. Ranade,P.S.(2008).*ClimateChangeandBiodiversity:PerspectivesandMitigationStrate gies*.ICFAIU niversitypress.
Outcomes	Oncompletionofthecourse,studentswillbeable ➢ tounderstandtheenvironmentalissues,energysystems,managementelatedtoclimatic change ➢ obtainindepthknowledgeofeffectofclimaticchangeonglobalsociety knowthewayinwhichsocietyworkswiththeeffectsofclimatechangeandclimateadapt ation.

Semester-IV					
Core		**Elective - 6**	**T/L /P**	**C**	**H/W**
Coursecode:		**NATURAL RESOURCE ANAGEMENT**	**T**	**3**	**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 o forests,Classificationofforestsformanagement,socialforestry,communityforestry.Indianforest policyandForestconservation.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 specie ofIndia, Wildlife conservation in India, Legislation: WLPA – 1972 and 2002 Amendment,developmentandImpactofwildlife,NationalParksandSanctuaries,GO's and NGO' s in wildlife conservation, 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.				
Reference and Text books:	1. SasikumarK(2009).*SolidWasteManagement*.PrenticeHallIndiaLearning PVLtd. 2. Patwardha nA.D(2017).*IndustrialWastewaterTreatment*.PHILearningPublication. 3. RamanathanJagbirSinghA.L(2019).*SolidWasteManagement:PresentandFutureChallenges.*DreamtechPress. 4. Pachauri,R.K.andSridharan,P.V.(1997),*LookingbacktoThinkAhead:GeenIndia*2047, TheEnergyResearchInstitute, New Delhi *5.* Dasmann,R. F. (1976),*Environmental Conservation*, John Willey and Sons, New York.WasiUllah,Gupta,S.K.andDalal,S.S.(1972),*HydrologicalMeasurementsforWatershed Research*, Jugal Kishore & Company.				

	6. Murty,J.V.S.(2017),*WatershedManagement*,NewAgeInternationalPublishers 7. Todd,T.KandMays,L.W.(2011),*GroundwaterHydrology*,Wiley.Agarwal,V.C. (2012), *GroundwaterHydrology*,PHILearning. 8. Klee.G.A.(1991),*Conservationofnaturalresources*,PrenticeHallPubl.Co.,NewJersey. 9. Owen.O.S.,Chiras,D.D.andReganold.J.P,(1998),*Natural resource conservation management for a sustainable future*, PrenticeHall.
Outcomes	➢ Oncompletionofthecourse,studentscanunderstandthewastegenerationprocess and characteristics of different types of solid wastes and ability to apply recycle by resource recovery technologies for useful conversion of specific waste type to eco-friendly products.

Semester-IV				
Course code: 22MES4S1	**SEC III**	**T/L /P**	**C**	**H/W**
	BIO MONITORING AND ECOLOGICAL ASSESSMENT	**T**	**2**	**4**

Objectives	• Acquire knowledge in physicochemical and biological changes in ecosystems • Enable the students to assess the habitat conditions based on biological indicators • Learn the general methods of biological indication of ecosystem health. • Apply knowledge in the construction and application of biomonitoring systems.
Unit-I	Definitions, strategies and principles for bioindication/biomonitoring of the environment. Causes of biological changes. Advantages of bioindicators over other types of indicators of the environment.
Unit-II	Types of bioindicators. Specific bioindicators. Biomarkers. Qualitative and quantitative indication of the environment. Saprobic system. Microbial indicators. Algae as ecological bioindicators. Lichens as indicators of air pollution. Bryophytes as bioindicators. Plants as bioindicators.
Unit –III	Ecological indices. Changes in plants indicating environment - invasive Plant communities - Agri-environmental indicators. Forests type and quality as indicators.
Unit- IV	Aquatic macrophytes as bioindicators. Plankton communities as indicators of water quality. Macroinvertebrates as indicators of water quality. Fish as bioindicators. Insects as indicators of terrestrial ecosystems. Terrestrial vertebrates as bioindicators.
Unit-V	Overview of Ecological Monitoring: Principal - concepts – need and significance. techniques applied Visual – instrumental; Global environmental monitoring system of UNEP – functions. World conservation monitoring Centre.

Reference and Textbooks:

1. Nalini, K.S. 1993 Environmental Resources and Management, Anmol Publishers.
2. Nautiyal, S and A. K. Kaul 1999 Forest Biodiversity and its Conservation Practices in India. Oriental Enterprises, Dehradun, India.
3. Negi, S. S 1993 Biodiversity and its Conservation in India. Indus Publications, New Delhi.
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Outcomes	On completion of the course, students will be able to have a brief knowledge in • Environmental pollution, • Importance of biological indicators in the ecosystem, • Global environmental monitoring system.