CURRICULUM OF
MASTERS' ACADEMIC PROGRAMMES

School of Environment & Natural Resources
(SENR)

Doon University
Kedarpur, P.O- Ajabpur, Dehradun – 248001

Programme Outcomes, and Course Outcomes of **M. Sc. Environmental Science**

M. Sc. Environmental Science

About the Programme

The Master in Environmental Science aims to give a broad appreciation of the major processes of environmental change and of the people and institutions involved in environmental protection. The course seeks to produce environmental experts/professionals who are interdisciplinary and analytical in their approach to environmental issues, and competent and aware decision makers.

Programme outcome

- Understand the relationship between social and natural systems by mastering the skills needed to develop solutions to environmental problems.
- Examine the ethical, cultural, economic and legal aspects of environmental responsibility and provide systemic solutions such remediation, mitigation and adaption towards environmental changes at different scales.
- Sensitize the students on the environmental issues and challenges at regional, national and global scale.
- Impart knowledge, practical training, analytical techniques and skills to solve the environmental problems.
- Prepare students for successful career in environmental departments in Universities and colleges, research institutes, industries, consultancy and NGOs, etc.

FIRST SEMESTER

Course Type	Course code	Course Title	Course outcomes
Core	EES-511	Ecology and Environment	❖ Understand the basic facts of population community and ecosystem level ecology and recognize the interconnections among the major concepts of ecology and environment. ❖ Be able to design an ecological study that addresses relevant questions, carry out the study using the appropriate equipment, and interpret and present the study to peers.

			❖ Investigate how the ecological concepts learnt in class relate to current environmental problems.
Core	EES – 515	Environmental Pollution	❖ Understand the basic facts of pollutants in air, water and soil system. ❖ Be able to clearly and concisely understand the difference between pollutants level and its impact on Ecology and Human life. ❖ Recognize the interconnections/ transportation of the pollutants in Environmental matrix and undertake measurement of pollutants: scientifically designing the sampling and data analysis.
Core	EES-521	Earth Surface and its Processes	❖ Learn about the significance of subject in ❖ Relation to Environmental Studies. ❖ Evaluate the geomorphic significance of anthropogenic activities. ❖ Understand the fundamental concepts of Earth surface and its processes in relation to Environment.
Elective	EES – 517	Environmental Chemistry	❖ Understand the role of basic chemistry principles behind different environmental process. ❖ Identify the origin and composition of Air, Soil, and aqueous environment and their physic-chemistry ❖ Understand the chemistry behind cause and transport of various pollutants in air, soil and water.
Elective	EES – 516	Environmental Impact Assessment	❖ Understand the major principles and different steps within the Environmental Impact Assessment. ❖ Be able to understand and access the different case studies in Environmental Impact Assessment. ❖ Plan for mitigation of the impacts & monitor the mitigation measures and acquire knowledge about Environmental Legislation & Environmental Audit.
General	EGC – 571	Environmental Issues, Laws and Policies	❖ Learn about the significance of development in International and National environmental law and fundamental principles that have emerged. ❖ Comprehending the statutory and regulatory mechanism pertaining to environment. ❖ Understanding the judicial response to Environmental issues in India.
General	EGC-596	Computational	❖ Master the basic techniques required to use and run the

		methods in Environmental science	climate models or environmental models. ❖ Gain skill with one of the computer programming language such as python. ❖ Gain skill in using computer programs to customize environmental models for specific purpose.

SECOND SEMESTER

Course Type	Course code	Course Title	Course Outcomes
Core	EES-513	Aquatic Environment	❖ Demonstrate a basic understanding of the physical, chemical, and biological characteristics of Aquatic ecosystems. ❖ Apply knowledge on aquatic ecosystems and environmental issues based on current research in a future profession inside or outside academia. ❖ Independently and in groups, plan and carry out field studies and laboratory experiments as well as compile, critically analyze and evaluate results.
Core	EES – 627	Environmental Microbiology & Biotechnology	❖ Impart the basic knowledge how to prepare and perform sampling and microbial analyses to determine the abundance, growth rate and microbial community composition in different environment. ❖ Understand the role of microbes in n degradation of natural organic compounds and selected pollutants in the environment. ❖ Learn how biotechnological tools can be used to study environmental assessment, monitoring and remediation.
Core	EES – 514	Geomatics	❖ Understand the principles of remote sensing and geographic information systems. ❖ Apply remote sensing and GIS to solving problems of Environmental Science and mapping of natural resources. ❖ Maximize the efficiency of planning and spatial decision making and integrate geographically referenced data and develop queries to generate usable information.
Core	EES – 618	Analytical	

		Techniques and Instrumentation	❖ Recognize the role of various analytical techniques in environmental monitoring. ❖ Understand the basic principles behind common analytical techniques and some important instruments. ❖ Able to perform qualitative and quantitative analysis of air, soil, and water samples.
Core	EES – 520	Atmosphere, Weather and Climate	❖ Understand the physical laws governing the structure and evolution of atmospheric phenomena. ❖ Demonstrate how atmospheric processes govern the air pollutants flow and dispersal in the air. ❖ Quantitatively analyze the weather phenomena, planetary boundary layer and its role in climate models.
Elective	EES – 551:	Environment Waste Management	❖ Understanding the major sources of environmental wastes and their impact on environment. ❖ Be able to participate in waste management program effectively. ❖ Learn about the development of innovative technologies to recover resources from waste resources.
Elective	EES – 555:	Hazards, Risk Analysis and Management	❖ Define hazard, hazard analysis, and risks, Job Safety Analysis, and Field Level Hazard assessment processes and how they lead to safe work procedures. ❖ Identify who is responsible for risk assessment and control, which risk assessment models are effective, and how risk assessments are performed.
General	EES 556	Society and Environmental Economics	❖ Apply economic principles to analyze specific environmental problems and issues; ❖ Identify the sources of 'market failure' (inefficiency) and the economic principles of pollution control; ❖ Utilize various 'instruments' developed by economists to deal with environmental problems to evaluate alternative courses of action for policy makers.

THIRD SEMESTER

Course Type	**Course code**	**Course Title**	**Course outcomes**
Core	EES-554	Statistics & Computer Applications	❖ Design proper sampling methods and its analysis an master different statistical techniques to analyze the data. ❖ Create quantitative **models** to solve real world problems in appropriate contexts. ❖ To skill themselves in using statistical software in

			visualizing, analyzing statistical models.
Core	EES – 518	Environmental Toxicology	❖ Understand the fundamental concepts of environmental toxicology and its application in human development. ❖ Recognizing the major sources of environmental toxicants and their management. ❖ Be able to develop concept for green chemicals for eco-toxicity mitigation
Core	EES – 619	Green Technology	❖ Appreciate the role and potential of technology in creating a safer environment. ❖ Become aware about evolving new techniques for clean energy, green buildings, green chemistry, resource reduction and pollution prevention. ❖ Enlist different concepts of green technology in a project.
Core	ENR – 556	Traditional Knowledge IPR Issue	❖ Understand current and emerging issues relating to the intellectual property protection, including those relating to indigenous knowledge or culture, information technology especially the distribution of material on the internet, biotechnology and international trade ❖ Understand fundamental legal principles relating to confidential information, copyright, patents, designs, trademarks and unfair competition; ❖ Understand the legal and practical steps needed to ensure that intellectual property rights remain valid and enforceable; ❖ Demonstrate a capacity to identify, apply and assess ownership rights and marketing protection under intellectual property law as applicable to information, ideas, new products and product marketing;
Elective		Optional From List of electives	
	EES –635	Field Study/Internship	❖ Apply their knowledge and skills acquired in the classroom to a professional context; ❖ Understand what skills are transferable to new contexts; identify and understand the practices and protocols of the particular Institution/Industry. ❖ Refine and reassess career goals as a result of the

			experience gained during internship.
	EES-680	Seminar	❖ Learn the presentation and discussion skills and develop critical thinking. ❖ Engage in big questions related to latest developments taking in field.

Elective Courses

Course code	Course Title	Course Outcomes
ENR-559	Disaster Management	❖ Understanding Disasters, man-made Hazards and Vulnerabilities. ❖ Understanding disaster management mechanism. ❖ Understanding capacity building concepts and planning of disaster managements.
ETC-530	Solid & Hazardous Waste Management	❖ Sampling and characterization of solid waste; analysis of hazardous waste constituents including QA/QC issues. ❖ Understand health and environmental issues related to solid waste management; apply steps in solid waste management-waste reduction at source. ❖ Learn about the collection techniques, materials and resource recovery/recycling,
EES- 615	Limnology & Chemical Speciation in Aquatic System	❖ Analyse and evaluate abiotic and biotic conditions in aquatic systems ❖ Account for structure and dynamics in biogeochemical cycles and organism communities ❖ Carry out basic sampling and analyses in freshwater field/laboratory systems
ETC-540	Air Pollution	❖ Identify the major sources and sinks of air pollutants. ❖ Understand the key chemical transformations of air pollution. ❖ Relate air pollution regulation and its scientific basis and provide solutions to air pollution problems.
EES- 530	Water Pollution	❖ Understand the chemical compositions of natural waters, and explain how and why these compositions vary, describe the main sources of water pollution, the main types of pollutant and how each type may be controlled ❖ outline the extent of water pollution in the country and in selected global locations ❖ identify the criteria for drinking water acceptability and outline the processes used to treat water for a public water supply
EES-625	Microbial Ecology	❖ Relate metabolic reactions carried out by microbes to global

		biogeochemical cycling of elements: understand the mechanisms how abiotic factors can influence on the microbial growth and microbial cells and how we can use this knowledge for controlling the growth of microorganisms. ❖ Understand how the specific environmental properties of soils, oceans and biofilms affect microbial communities therein. Understand relations between microorganisms and plants, animals and man. ❖ Describe the distribution and role of microorganisms in different habitats such us atmosphere, water ecosystems and soil.
EES-570	Global climate change and its impacts	❖ understand the current evidence for global warming, model and apply the techniques of 'measuring' the Earth's temperature. ❖ understand the current warming in relation to climate changes throughout the Earth's history ❖ explain factors forcing climate change, and the extent of anthropogenic influence and assess the 'best predictions' of current climate models.
ENR-560	Soil science and Soil ecology	❖ Describe the various mineral and organic components of soils, including how changes in various quantities affect soil physical and chemical properties. ❖ Understand pedogenesis and how different parent materials create soils with varying properties. Understand water retention and movement in soils, especially as it relates to plant water availability. Develop basic understanding of soil chemistry, including pH and CEC, especially how they relate to nutrient availability and, when feasible, adjustments, such as liming, that can improve conditions for plant growth. ❖ Develop an introductory understanding of soil taxonomy, including the various insects, microbes and other organisms.
ENR-552	Trees outside forest	❖ Understand the significance of various tree farming practices in ecosystem services. ❖ Understand and appreciate the importance of tree in urban context. ❖ Develop suitable models for creating urban green spaces.
ETC-510	Water and Wastewater engineering	
ENR-515	Integrated Watershed management	❖ Suggest technical measures for soil erosion control both due to water and wind, ❖ Assess the current status of the watershed at field, by taking

		up accurate investigation measures and conduct survey. ❖ Suggest drought control measures, water conservation structures, including design
EES-612	Science of climate change	❖ Understand natural and human-influenced drivers of our climate system and implications. ❖ Assess the credibility of scientific information and l communicate locally-relevant climate change solutions to a non-science audience ❖ Make informed & responsible decisions with regard to our climate system
EES-614	Environmental Modeling	❖ To explain the physical and chemical laws basis of environmental models. ❖ To learn skill of running air quality models, water quality models. ❖ To skill themselves in applying these models in specific area under specific scenario.
EES-621	Environmental Biochemistry and Biophysics	❖ Understand biochemical degradation of pollutants inside the Cell, Cellular interactions with pollutants, and Pollutant interactions with biological systems at different levels. ❖ Understand about the metal toxicity in cell and bio interaction of cell with the environment. ❖ Use databases, computational tools and online resources effectively.

FOURTH SEMESTER

Course Type	Course code	Course Title	Course outcome
Core	EES-690	THESIS/DISSERTATION	❖ Plan, and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic relevant to environment and society. ❖ Systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. ❖ Appropriately apply qualitative and/or quantitative evaluation processes to original data. ❖ Understand and apply ethical standards of conduct in the collection and evaluation of data and other resources, communicate research concepts and contexts clearly and effectively both in writing and orally.

Credit requirement and course outline of M.Sc. Environmental Science

Minimum credit requirement (64 credits)

M.Sc. Environmental science

Semester	Minimum Credit requirement			Field Study/Internship	Seminar	Dissertation	Total Credits
	Core	Elective	General				
Semester-1	9	5	4	-	-	-	18
Semester-11	15	5	3	-	-	-	23
Semester-111	9	3	2	4	1	-	19
Semester-1V	10	-	-	-	-	10	10
	33	**13**	**9**	**4**	**1**	**10**	**70**

FIRST SEMESTER **Total Credits: 18**

S.No	Course Type	Course code	Course Title	Credit	L-T-P
1.	**Core**	EES-511	Ecology and Environment	3	2-0-1
2.	**Core**	EES – 515	Environmental Pollution	3	2-0-1
3.	**Core**	EES-521	Earth Surface and its Processes	3	3-0-0
4.	**Elective**	EES – 517	Environmental Chemistry	3	2-0-1
5.	**Elective**	EES – 516	Environmental Impact Assessment	2	2-0-0
6.	**General**	EGC – 571	Environmental Issues, Laws and Policies	2	2-0-0
7.	**General**	EGC-596	Computational methods in Environmental science	2	1-0-1

SECOND SEMESTER **Total Credits: 23**

Sl.No	Course Type	Course code	Course Title	Credit	L-T-P
1	**Core**	EES-513	Aquatic Environment	3	2-0-1
2	**Core**	EES – 627	Environmental Microbiology & Biotechnology	3	2-0-1
3	**Core**	EES – 514	Geomatics	3	2-0-1
4	**Core**	EES – 618	Analytical Techniques and Instrumentation	3	2-0-1
5	**Core**	EES – 520	Atmosphere, Weather and Climate	3	3-0-0
6	**Elective**	EES – 551	Environment Waste Management	3	2-0-1
7	**Elective**	EES – 555	Hazards, Risk Analysis and Management	2	1-1-0
8	**General**	EES 556	Society and Environmental Economics	3	3-0-0

THIRD SEMESTER **Total Credits: 19**

SL.No	Course Type	Course code	Course Title	Credit	L-T-P
1	**Core**	EES-554	Statistics & Computer Applications	3	2-0-1
2	**Core**	EES – 518	Environmental Toxicology	3	2-0-1
3	**Core**	EES – 619	Green Technology	3	2-0-1
4	**Elective**		Optional From List of electives	3	
5	**General**	ENR – 556	Traditional Knowledge IPR Issue	2	2-0-0
6		EES –635	Field Study/Internship	1+3	
7		EES-680	Seminar	1	

FOURTH SEMESTER **Total Credits: 10**

S.No	Course Type	Course code	Course Title	Credit
1	**Core**	EES-690	THESIS/DISSERTATION	10

List of Optional/Elective Courses to be offered in Third Semester:

Sl.No	Course code	Course Title	Credit
1.	ENR-559	Disaster Management	3
2	ETC-530	Solid & Hazardous Waste Management	3
3	EES- 615	Limnology & Chemical Speciation in Aquatic System	3
4	ETC-540	Air Pollution	3
5	EES- 530	Water Pollution	3
6	EES-625	Microbial Ecology	3
7	EES-570	Global climate change and its impacts	3
8	ENR-560	Soil science and Soil ecology	3
9	ENR-552	Trees outside forest	3
10	EES-559	Environmental Biochemistry and Biophysics	3
11	ETC-510	Water and Wastewater engineering	3
12	ENR-515	Integrated Watershed management	3
13	EES-612	Science of climate change	3
14	EES-614	Environmental Modeling	3

Courses with astrix(*) will be offered on the availability of faculty

DETAILED M.Sc. EVS Syllabus

EES-511: Ecology & Environment Credits 3 (2-0-1)

Unit 1: Introduction of Environmental Studies: Multidisciplinary nature of Environmental Sciences – Definition, Scope and importance; Environmental Issues; Need for public awareness and participation

Unit 2: **Ecology and Ecosystems:** Introduction, Ecological factors, Ecosystems, Comparative Ecosystem ecology, Ecosystem degradation and desertification, modeling

Unit 3:Population Ecology**:** Definition, Structure and measurements, Population growth, Population regulation, Strategies of species survivability, Population Genetics, Human population

Unit 4: Community Ecology: Concepts of community, community gradients, Characters of community, Ecological succession and climax, Community organization, Interaction between species; Vegetation of India; Stress Ecology and adaptation

Unit 5: Applied Ecology: Estimating Abundance; Species diversity measures, Biomass productivity and estimation

Unit 6: Biodiversity: Definition, Composition and levels, Value and Distribution Patterns, Hot Spots, Threats to biodiversity, Assessment, Characterization and Monitoring, Valuation, Rare, Endangered and Threatened species, endemic species, Plants and animals in IUCN Red Data List Categories their conservation measures, International , National and Regional Biodiversity initiatives

Suggested Readings:

Text Books:

1. E. P. Odum Fundamentals of Ecology, Sunderland, 1996
2. E.J. Kormondy Concepts of Ecology, Prentice Hall of India, 1994
3. Botkin, Daniel B. (2011) *Environmental Science: Earth as a Living Planet*, John Wiley and
4. Sons, New Delhi.
5. Miller, G. Tyler and Scott Spoolman (2011) *Essentials of Ecology*, Brooks/Cole Learning,
6. USA.
7. Odum, E. P. (1996) *Fundamentals of Ecology*, Nataraj Publisher, Dehra Dun.
8. Dakshini , K.M.M. (1999) *Principle and Practices in Plant Ecology*, CRC, Boston

EES-515: Environmental pollution: **Credits 3(2-0-1)**

Unit 1: Air Pollution: Air pollutants, transport, diffusion and reactions of pollutants in the atmosphere, Impact of air pollutants on human beings, animals and climate, plants, materials, buildings, water bodies, Methods of monitoring and control of air pollutants; Ambient Air quality standards.

Unit 2: Water Pollution: Types, source and impacts- surface and ground water, Domestic, Industrial, Agricultural and Natural sources, Impact on plants, human, animals and environment, Water quality studies-quality parameters, sampling, analysis for pH, EC, turbidity, solids- TDS, acidity, alkalinity, hardness, chloride, salinity, DO, CO2, BOD, COD, Nitrogen, phosphate, sulphate, Cadmium, Microbiological analysis- *E. coli* and its population, Water quality standards; **Water pollution control:** Pollution due to municipal severage dumping, industrial effluent discharge, solid waste dumping – leachate, infiltration, Assessment of level of pollution, Waste water treatment: an overview

Unit 3: Soil Pollution: Sources of soil pollution- natural, Anthropogenic; Soil pollution monitoring, Remediation of polluted soil

Unit 4: Pollution due to plastic waste: Types of plastic waste, quantity and its source, pollution of water bodies, drains, sewage; Soil pollution- assessment of level of pollution, Impact on soil quality, Control measures- Role of society and civic bodies

Unit 5: Noise pollution: Sources and impact, monitoring noise pollution and abatement measures

Suggested Readings:

1. Introduction to Environmental Engineering science (Third editn): Masters & Ela (PHI)

2. Atmospheric chemistry and Physics: Seinfeld & Pandis., John wiley & sons

3. Introduction to aerosol science. P C Reist (Macmillan pub)

4. Trace elements in the Terrestrial Env (D C Adriano) Springer –Verlag)

5. Environmental science, technology, and chemistry: Manahan, S: CRC

EES 521: Earth Surface & its Processes **Credits 3(3-0-0)**

Unit 1: Introduction to physical system: Earths, interior, Rock types, Earth surface processes, weathering of rocks, Mass wasting, Erosion, Transportation and deposition of earth's material by running water, Role of geological aspects in environmental science, mountain building, plate tectonics, continental drift, Mechanics and classification of folds and faults.

Unit 2: The earth systems and Biosphere: Conservation of matter in various geo spheres – lithosphere, hydrosphere, and atmosphere and biosphere Energy budget of the earth. Earth's thermal environment and seasons, Earthquake, Volcanoes and Tsunamis.

Unit 3:Mineral Resources and Environment: Resources and Reserves, Minerals and Population Oceans as new areas for exploration of mineral resources. Ocean ore and recycling of resources. Environmental impact of exploitation, processing and smelting of minerals. **Land use Planning:** The land use plan. Soil surveys in relation to land use planning. Methods of site selection and evaluation

Unit 4: Environmental Geochemistry: Concept of major, trace and REE. Geochemical cycles. Classification of trace elements, Mobility of trace elements, Biogeochemical factors in environmental health. Human use, trace, biogeochemical factors in environmental health. Human use, trace elements and health.

Suggested Readings:

Text Books:

1. A. C. Fortescue Environmental Geochemistry, Springer-Verlag, 1980
2. A. H. Bownlow Geochemistry, Prentice Hall, 1978
3. G. Faure and T. M. Mensing Isotopes: Principles and applications, John Wiley and Sons, 2004
4. J. A. Plant and R. Raiswell Principles of Environmental Geochemistry, New Academic Press, 1983
5. J. V. Walther, Essentials of Geochemistry, Jones and Barlettt, Massachusetts, 2005
6. C.W. Montgomery Environmental Geology, 7th edition, Mc. Graw Hill, 2006

References:

7. D. N. Wadia Geology of India, Mac Milan, 1939
8. G.H. Speidel and A.F. Agnew the Natural Geochemistry of Our Environment, West View Press, 1982
9. Mont-Gomery Rocks and Minerals, Wm. C. Brown Publisher, 1992
10. S. E. Manahan Environmental Chemistry, Lewis, 1994
11. Don J. Easterbrook (1998) Surface Processes and Landforms, 2nd edition, Prentice Hall, 1998
12. John Bridge and Robert Demicco (2008) Earth Surface Processes, Landforms and Sediment Deposits Cambridge University Press, 2008.

EES-517: Environmental Chemistry **Credits 3 (2-0-1)**

Unit 1:Fundamentals of Environmental Chemistry: Stochiometry, Chemical kinetics, Thermodynamics, chemical equilibrium, acid base reactions, Redox reactions and Redox potential, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, radionuclides

Unit 2: Chemistry of Air: Classification of elements, chemical speciation History of evolution of the earth's atmosphere, Role of chemical constituents in atmospheric process, Particles, ions and radical in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere. Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical smog, Acid rain and ecological Effects.

Unit 3:Chemistry of Water: Composition and structure, physical properties, and aqueous solutions, Concept of DO, BOD, COD, sedimentation, coagulation, filtration, redox potential. Solubility of solids, liquids and gases in water.

Unit 4:Chemistry of Soil: Formation of soil, Soil profile and classification of soil, Gross composition, Organic and inorganic components, Physico-chemical characteristics, Ion exchange and adsorption process, Fate of chemicals, Wastes and pollutants. Inorganic and Organic component of Soil, Nitrogen pathways and NPK in soils.

Suggested Readings

Text Book

1. Girad J. (2011) *Principals of Environmental Chemistry*, Second Edition, Jones & Bartlett Publisher.
2. Puri B.R., Sharma L. R., Patahania M. S. (2003) *Principal of Physical Chemistry*, Vishal Publishing Com.
3. Manahan S. E. (2010) Environmental Chemistry, Ninth Edition, CRC Press.
4. Srivastava M. M., Sanghi R. (2005) *Chemistry of Green Environment*, Narosa Publishing House.
5. De A. K. (2003) *Environmental Chemistry*, Fifth Edition, New Age International.

EES-516: Environmental Impact Assessment (EIA) Credits 2 (2-0-0)

Unit 1: Introduction to Environment Management: Basic Principles, Watershed, Land use and Wet land management, Principles and practice of ecosystem modeling, Introduction to environmental quality models – input and output models, linear programming models of environmental management;

Unit 2: EIA: Introduction- Definition, aim, principles, concepts, scope, Methods and steps, EIA monitoring, modeling and risk assessment, Environmental Auditing; **EIA Process:** Methods for preparing EIA, Impact prediction, Basic steps for prediction and assessment of air, water and biological environment; **EIA for different environmental programmes:** Industries, Urban development Land use Energy projects, Development projects, Resource Management, EIA Case studies; Introduction to environmental planning. Base line information and predictions (land, water, atmosphere, energy etc.).

Unit 3: Environmental Planning and Management (EPM): Principles of EPM, Environmental Analysis and EPM; Environmental Planning and management, Land-use policy for India and urban planning for India with special reference to Himalayas, Rural planning and land-use pattern, Cost –benefit analysis, Environmental priorities in India and sustainable development. EIA process; Evaluation of proposed actions, scoping EIA

Unit 4: Role of GIS in EIA base line study, risk assessment and risk management. Mitigation, Green belts. Review of procedures, practices and guidelines in India. Case Studies- River valley projects, Thermal power plants, Mining projects, Oil refineries and petrochemicals, with reference tofields of Himalayn region, Current topics on Environmental Impact Assessment.

Suggested Reading:

1. D. P. Lawrence Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley and Sons, 2003
2. Glasson, Therivel and Chadwick An Introduction to Environmental Impact Assessment, UCL, 1999
3. P. Morris and R.Therivel Methods of Environmental Impact Assessment, Spoon Press, 2001
4. L. Carter Environmental Impact Assessment, McGraw Hill, 1996
5. Y. Anjanejuly Environmental Impact Assessment Methodologies, B.S. Publications, 2002
6. Weston, Planning and EIA in Practice, Longman, 1997
7. Charles, H. Eccleston (2011) Environmental Impact Assessment, CRC Press, New York
8. Anjanejuly , Y. (2002) Environmental Impact Assessment Methodologies, B.S. Publications, New Delhi.
9. website of MoEF, GOI, New Delhi
10. Srivastava, D. C. (2005) Readings in Environmental Ethics: Multidisciplinary perspectives, Rawat Publications, Jaipur.

EGC-571: Environmental Issues, Laws and Policies **Credits 2 (2-0-0)**

Unit 1: Significance of global issues and their inter-linkage. Policy response of UN and countries in solving international problems. United Nations Conference on Environment & Development: Agenda 21Kyoto protocol to the United Nations framework convention on climate change.,

Unit 2: Science of Climate Change; Impact of Climate Change; Policy Responses to Climate Change; Approaches and Programmes Responding to Climate Change; Linkages of UNFCCC with other International Conventions., Climate change action plan The Vienna Convention for the Protection of the Ozone Layer & The Montreal Protocol Stockholm Convention on Persistent Organic Pollutants (POPs) Convention on biological diversity and their protocol (Cartagena, Nagoya protocol,) Basel convention on the control of trans-boundary movements of hazardous wastes and their disposal

Unit 3: Introduction: Brief history of environmental regulations in the World, Role of UN in Environmental Policies and Law, Stockholm declaration – 1972, Hague Declaration – 1989, Rio Declaration – 1992, Fundamental principles of International Environmental laws; **Environmental Policy in India:** Environmental Legislation Protection Laws in India- Ancient and Pre-Independence, Forest Policies and Legislation in Pre-Independence period, Environmental Legislations in Post-Independence Period, Constitutional and Legislative Provisions in India, Judicial Remedies and Procedures, Labeling of Environment friendly products;

Unit 4: Laws Relating to Control of Pollution and Environment in India: Pollution Control Board and its activities, powers, Water Act and related Acts, Rules and Regulations, Noise and Land Pollution Rules and Regulations, Rules and Notifications made under Environmental (Protection) Act 1986; **Hazardous Waste Management:** Rules, Hazardous microorganisms, Biomedical Waste management, Recycled plastics, Ozone depleting substances, Solid waste management, etc.; Forests and Wildlife Protection Act and Rules.

Suggested Readings

Text Books:

1. P. Sands Principles of International Environmental Laws, Cambridge University Press, 2003
2. S. Divan and A. Rosencrantz Environmental Law and Policy in India: cases, materials and statues, Oxford University Press, 1995
3. G. Singh, Environmental Laws in India, McMillan Publisher, 2005

References:

4. D. D. Basu Introduction to the Constitution of India, Wadhwa and Company Law Publisher, 2003
5. S.K. Choudhury, Environmental Legislation in India, Oxford IBH, 1996
6. V. H. Heywood and R. T. Watson Global Bio-diversity Assessment, Cambridge University Press, 1995
7. V.K. Prabhakar International Laws on Bio-Diversity, Annal, 2001
8. R.K. Trivedi Handbook of Environmental Laws, Acts, Guidelines, Compliance and Standards, Vol I & II, B.S. Publications, Hyderabad, 2004

9. The Vienna Convention for the Protection of the Ozone Layer & The Montreal Protocol on Substances that Deplete the Ozone Layer., United Nations Environment Programme

EGC596: Computational Methods in Environmental Science Credit: 2 (1-0-1)

Unit 1. Introduction to Computational Methods for Environmental Science, , Introduction to Python or MATLAB or FORTRAN, Basics of programming – Design Principles-control flow-execution steps-desirable & undesirable characteristics, Conditional statements, Functions — calling Functions – Passing arguments- Arrays – Defining and processing an array – Array Functions-Passing arrays to Functions – Multidimensional Arrays – Strings-arrays of Strings-String Manipulation functions, General Characteristics of Object Oriented programming

Unit 2. Numerical methods : Solution of Algebraic and transcendental equation, The Bisection Method, iteration method, Newton-Raphson method, Interpolation, Finite differences, Forward differences, backward differences, Numerical differentiation and integration, Simpson's 1/3-rule, Simpson's 3/8 rule, Romberg integration, Matrices and linear system of equations, Rank, inverse of a Matrix, Gauss elimination method, LU decomposition Eigenvalue problem, SVD, Numerical solution of ordinary differential equations, Runge-Kutta Method

Unit 3. Applications: Gaussian Plume Model, DO &BOD: Oxygen sag model, Prey-Predator Model (Lotka-Volterra Model), Analysis of Remote Sensing data such as MODIS, OMI

Suggested Readings:

1. Introduction to Numerical Analysis: S. S. Shastry, Prentice Hall of India
2. Numerical Analysis Using MATLAB and spreadsheets: Steven T. Karris, Oxford publications
3. A Primer on Scientific Programming with Python: Hans Petter Langtangen, Springer
4. Introduction of Environmental Science &Engineering: Gilbert M. Masters

EES-513: Aquatic Environment **Credits 3(2-0-1)**

Unit 1: Introduction to aquatic system, physicochemical properties of fresh water; Heat budget of water bodies; Oxygen and other dissolved gases;

Unit 2: Life in Fresh water: Phytoplankton, periphyton, zooplankton, fish, benthic organisms and Macrophytes; Microbiology of freshwaters; Primary and Secondary production, Production Processes and factors influencing them; Food-chain dynamics and energetic; Detritus and Carbon cycle; Comparative study of lentic and lotic ecosystems;

Unit3: Wetland & Estuarine ecosystem: Introduction, Types and functions, life in wetlands, Conservation of wetlands, Ramsar convention. Land-water interactions; estuaries-mangroves- lagoons- salt marshes.

Unit 4 : Marine ecosystem: Introduction-Classification- open ocean- shallow marine and deep sea environment- marine resources- marine ecology- marine organisms-productivity- coastal environment-coastal water movement- beaches- coastal dunes- barrier islands- cliffed coast- deltas-coast line- coral reefs.

Unit 5: Chemical processes in the aquatic environment with respect to chemical nature of water; sources, pathways and reservoirs of contaminants in aquatic systems. Applied Limnology; Water Pollution, Eutrophication; Wastewater treatment, Water quality management and modeling; Aquaculture; Water quality standards; Monitoring water quality; Methods of water and wastewater analysis.

Suggested readings

Text Books:

1. Garrison**,** Tom S.Essentials of Oceanography 7th Edition
2. G. Tyler Miller's: Living in the Environment14th Edition
3. Wetzel, R.G., 2001. Limnology: Lake and River Ecosystems.Third Edition. Academic Press, 1006pp.

EES-627: Environmental Microbiology & Biotechnology Credits 3 (2-0-1)

Unit 1: Introduction: Scope and history of Microbiology, Characteristics of microorganisms and their role in environment, Primary description of protozoans, algae, fungi, bacteria, viruses, and mycoplasma**; Bacteria:** Morphology and ultra-structure of bacteria, Nutrition – Autotrophy and heterotrophy, Microbial growth-cytological and population growth, Isolation, purification, maintenance and characterization of microbes.

Unit 2: Microorganisms and the Environment: Physiological status of microorganisms in the environment, Foreign derived microorganisms – survival and fate, Genetically engineered microorganisms – fate and effects, Microorganisms in extreme environments, Nature of marine and freshwater environments, Air microbiology, Water microbiology, Food microbiology, Industrial microbiology, Soil microbiology, General account of disease causing microorganisms;

Unit 3: Cell Technology and Environmental Biotechnology: Cell Structure and Function – bacteria, plant and animal cell, nucleic acids, protein synthesis, gene regulation in prokaryotes, Microbial nucleic acids, Genetic control of metabolism, Recombinant DNA (rDNA) techniques, Tissue culture concept of rDNA technology, Principles of Plant Genetic Transformation – tools, techniques and methodologies, Environmental Biotechnology – definition, principles and scope; **Biotechnological Methods in Pollution Control:** Air pollution control, Water pollution control, Bioremediation, Biosensors; **Emerging Trends in Environmental Biotechnology:** Agrobiotechnology - transgenic plants for sustainable agriculture, Biotechnology for germplasm conservation and management of PGRs, Molecular Biology, Genetic Engineering and Tissue Culture:

Unit 4: **Ecological Engineering** – lateral gene flows, Biodegradable plastics, Phytoreactors, Other technologies such as biochips, biofilms, biosurfactants microprobes, nanotechnology, Biotechnological Applications in pesticide industry, tannery, paper and pulp industry, food and allied industries, Impact of Genetic Engineering on Environment, Impact of modern biotechnology on biodiversity and environment – relevance of biosafety and biotech regulations, regulatory framework of India.

Unit 5 :Types of Microbes and their Isolation and Preservation: Aerobic and anaerobic microbes, Isolation procedures, growth media, Purification of mixed culture, Gram negative, Gram positive microbes, Preservation Techniques; **Characterization and Identification of Microbes:** Procedures for characterization of microbes, Biochemical characterization, Substrate Utilization profile, Identification of microbes by fatty acid methyl ester analysis and sequence of 16S rDNA**;** Degradation of Different Fraction of Total Petroleum Hydrocarbon: Degradation of alkane fraction and pathway of degradation of alkenes; Degradation of polycyclic aromatic hydrocarbons (PAH), Pathway of degradation of PAHs; Screening of Microbes for Degradation of PAHs by PCR based Techniques.

Suggested Readings

Text Books:

1. Gareth M, Evans, Judith C, Furlong, Environmental Biotechnology: Theory and Application, John Wiley and Sons, 2002
2. Yuan Kun Lee, Microbial Biotechnology: Principles and Applications, 2nd Edition, World Scientific Publisher, 2006
3. P.K. Mohapatra, Text book on Environmental Biotechnology, I. K. International, New Delhi, 2007

4. P. K. Jjemba Environmental Microbiology, Science Publication, USA 2003
5. Abbasi, S. A. and E Ramasami (1999) *Biotechnological methods of Pollution control* University Press, Hyderabad.
6. Alan Scrogg (2005) *Environmental Biotechnology*, (II ed.), Oxford University Press, New York.
7. Pelczar, Jr. M. J, Chan, E.C.S. and Krieg, N. R. (2009) Microbiology, (V Edition), Tata McGraw-Hill New Delhi.

References:

1. G. Rangswami, D. J. Bagyaraj *Agricultural Microbiology*, Prentice Hal of India, 2004
2. N.S. Subbarao and Y.R. Dommergues (edtrs.) *Microbial Interactions in Agriculture and Forestry Voll I & II*, Science Publisher, 2004
3.A.K. Chatterjee, Introduction to Environmental Biotechnology, Prentice Hall of India, 2004

ENR-514: Geomatics Credits 3 (2-0-1)

Unit 1: Photogrammetry and Cartography: Basics of map reading, Marginal information of maps, types and sources of maps, cartographic representation of data, map coordinate system, projections and their types and guidelines for preparation a base map, thematic mapping.

Unit 2: Basics of Remote Sensing: Types of remote sensing, platforms and sensors; active and passive sensors, aerial photographs, satellite images, radars; sensors and temporal Types of remote sensing, platforms and sensors; active and passive sensors, aerial photographs, satellite images, radars; sensors and temporal Image interpretation- elements and methods: visual and digital

Unit 3: Digital Image Processing: Concepts of Digital Image Processing, Data and Image storage formats, Image Preprocessing, Radiometric correction, Spatial and frequency domain filtering, Image Classification, Image Fusion

Unit 4: A **Geographic Information System & GPS:** Basic concepts and components of GIS; features types Spatial data models (raster and vector)- their advantage and disadvantages Spatial data creation and management-methods, topology creation, editing and manipulation, attaching attribute data Spatial analysis: Single and multilayer spatial analysis Spatial querying; arithmetic and logical operations Spatial querying; arithmetic and logical operations Spatial data visualization- map design and layout for thematic layers and display of tables and graphs using GIS software **Global Positioning System (GPS):** Introduction to GPS FunctionsField operations of GPS and data collection using GPS

Suggested Readings

1. Dewitt Bon A. and Paul Wolf (2000): Elements of Photogrammetry, McGraw Hill.
2. George Joseph (2005): Fundamentals of Remote Sensing; Universities Press (India) Pvt. Ltd, Hyderabad, India.
3. Lillesand Thomas M., Kiefer Ralph W. and Chipman Jonathan,(2008): Remote Sensing and Image Interpretation, 6th Edition, John Wiley.
4. Jensen, John R. (2000): Remote Sensing of the Environment: An Earth Resource Perspective, New Jersey: Prentice Hall, 544 pages.

5. Longley, Paul A., Goodchild, Michael F., Maguire, David J., and David W. Rhind. (2005) Geographic Information Systems and Science, 2nd ed., John Wiley and Sons, Toronto.
6. Burroughs, P.P. & McDonnel, R.A. (1998) Principles of GIS, Oxford University Press, pp. 162 -166.
7. Introduction to Geographic Information Systems, Kang-tsung Chang

EES 520: Atmosphere, Weather & Climate Credits 3 (3-0-0)

Unit 1: Origin of earth's atmosphere and historical development in Atmospheric Sciences, Physical and Chemical composition of the atmosphere and stratification

Unit 2: Laws of radiations, emissions, absorption and scattering, Radiation budget of earth's atmosphere system, Green house effect, thermodynamics of the atmosphere, Lapse rate of dry and moist atmosphere.

Unit 3: Mixing height, cloud formation and classification, Precipitation Processes, Hydrostatic balance and atmospheric stability, scales of atmospheric motions, wind, pressure and circulating systems, Atmospheric general circulation and role of earth rotation.

Unit 4: Weather monitoring and measurement, Tropical weather and climate, Monsoons, tropical cyclones, extra tropical weather systems and mountain weather, Climate and Climate Change, Global and regional microclimates

Suggested Readings

Text Books

1. C. Donald Ahrens Meteorology Today – An introduction to weather, climate and the Environment Brooks/Cole Thompson Learning
2. J.E. Oliver and J.J. Hidore Climatology and atmospheric science
3. P.A. Menon Our Weather, NBT
4. H.J. Critichfield, General Climatology, PHI, 2002

References:

5. P.K. Das Monsoon, NBT
6. W.S. Burrough, Climate change; A multidisciplinary Approach, CUP, 2007
7. Gorden Dynamic Meteorology - A basic course, Arnold, 1998

EES-618: Analytical Techniques and Instrumentation Credits 3 (2-0-1)

Unit 1: Basic Tools and Operations of Analytical Techniques: Sampling, Preservation, Storage, and processing of air, water and soil samples, Laboratory Safety.

Unit 2: Gravimetric Methods of Analysis: Determination of total, dissolved, suspended, volatile and fixed solids, Estimation of moisture content of soil, phytomass, and compost/ vermicompost;

Unit 3: Volumetric Methods: Importance of volumetric analysis, Standardization of reagent using volumetric reactions, Acid-base titrimetry, Complexometric titrations.

Unit 4: Electrochemical Methods: pH meter, Electrical conductivity meters, measurements;

Unit 5: Photometric Methods: Nephalometry, Turbidometry, Calorimetry,

Unit 6: SpectrophotometryUV-Vis Spectrophotometry, Flame photometry, Atomic absorption spectrophotometry, Dosimetry;

Unit 7: Chromatography: Theory and principles, Paper chromatography, thin layer chromatography, Column Chromatography, Gas Chromatography, GC – MS, High Performance Liquid Chromatography (HPLC, FPLC)

Unit 8: Electrophoresis: Theory and Principles, Gel electrophoresis, Immunoelectrophoresis;

Unit 9: Microscopy: Light microscopes- light, dark field, fluorescence microscopy; Electron Microscopes – transmission and scan

Suggested Readings

Text Book

1. Quantitative Chemical Analysis, 8th Edition, by Daniel C. Harris, W. H. Freeman and Co., 2006, ISBN: 9781429218153.

2. The Solutions Manual for Quantitative Chemical Analysis 8th Ed. (ISBN 9781429231237).

3. Principles of Instrumental Analysis, Fifth Edition, Skoog, Holler, Nieman.

4. Analytical Chemistry by Gary D. Christian.

ENR – 556: IPR & Traditional Knowledge 2 (2-0-0)

Unit 1: Introduction; Intellectual Property Rights, Introduction to IPR – What is intellectual property? Genesis of IPR (WIPO, GATT, TRIPs)

Unit 2: Types of intellectual property – Patents; Plant Breeders Rights; Geographical Indications; Copyrights; Trademarks, Industrial Designs, Trade Secrets, Layout Design for Computer Circuits;

Unit 3: Patents – Patent system terminologies, Categories of patents, Preparation of patent, Criteria for patenting, Patent specification – standard format, Typical patenting procedure, Rights of a patentee, Uses of patent system, Prior art, Indian patent system, patent search and database, Patent drafting, Patent infringement.

Unit 4: IPR and Biodiversity;Traditional Knowledge and its Control; Action, Resistance and Alternatives; International Agreements and Negotiations; Indian Legislation.

Suggested Readings:

1. WIPO document

2. Patent laws in India

3. Journal of Traditional Knowledge

EES-551: Environmental Waste Management Credits 3 (2-0-1)

Unit 1: Introduction: Solid waste: Public health and ecological impacts, Sources and types of solid wastes, material flow and waste generation in a technological society, factors affecting the generation rates. Municipal solid waste (MSW)**:** physical and chemical composition, factors affecting MSW quality and quantity, hierarchy of waste management options, RCRA, integrated solid waste management concept. R3 strategy, Overview of solid waste generation and management practices in India. Legal framework for handling and storage of municipal, medical and hazards wastes in India.

Unit 2: Waste Storage, Collection and transportation: Storage: movable bins, fixed bins. MSW Collection: home-to-home collection, community bin system. Container system, stationary container system, Transfer and transport, processing, waste transportation system, waste: separators, size reduction equipments, screening equipment, Material recovery facility. Electronic waste and construction/demolition waste – storage and treatment options. Waste disposal system and health and pollution issues with waste handling and disposal system.

Unit 3: Waste recycling and waste-to –energy concept – Waste recycling - role of formal and informal sector, community waste recycling; resource derived fuels (RDF)- concept, processing, application and limitations, waste-to-energy, waste calorific value assessment, sources, concept, Thermal conversion

technologies: incineration and pyrolysis system, energy recovery, system, technologies-gasification, pyrolysis, biogas, fuel from wastes and char; limitation and health issues. Composting and vermicomposting –, types of composting, process description, design and operational consideration of aerobic composting, process description, design and operational consideration of anaerobic composting.

Unit 4: Sanitary Landfill and Incineration Technology: Land-filling: Site selection criteria, landfill layout, landfill sections, Occurrence of gases and, leachate in landfills: composition and characteristics, operation control, waste decomposition phases in sanitary landfill, gas control and utilization, flaring system. Bioreactor landfill- types and operation management, Post closure operations in landfill. Incinerator technology– concept, engineering and applications, incinerator system for MSW, thermal processing system, different units of a typical incinerator, unit operations, fuel gas controlling, air pollution control in incineration, residual management, legal, political and social issues with incineration technology.

Unit 5:Hazardous Waste: Hazardous wastes, types, sources, composition and classification. Storage-onsite and offsite storage, hazardous waste transportation, International trade/export/ import of hazards waste, Basel Convention, hazardous waste treatment methods- criteria for treatment selection, land disposal, combustion, solidification. Medical waste storage and treatment, residues management in hazardous waste treatment.

Suggested Readings

1. EPA, 1995. *Decision-Makers' Guide to Solid Waste Management*, Vol-I & II. US EPA, Washington, D.C.
2. FAO 2003. On-farm Composting Methods. FAO, Rome.
3. *Guidelines for Management and Handling of Hazardous wastes* MOEF (1991), Govt. of India.
4. Kaily, G. 19997. *Environmental Engineering*. The McGraw-Hill Companies, New York, NY.
5. Liu, D.H.F., and Liptak, 2000. B.G. *Hazardous Waste and Solid Waste*, Lewis Publishers, Boca raton, FL.
6. Pichetel, J. 2005. *Waste management Practices – Municipal, Hazardous, and Industrial*. Taylor and Francis, Boca Raton, USA. 659 pp.
7. Reinhart, D.R., and Townsend, T.G. 19997. *Landfill Bioreactor Design and Operations*. Lewis Publishers, New York, NY.
8. Tchobanoglous, G., and Kreith, F. 2002. *Handbook of Solid Waste Management.* McGraw Hill, New York.
9. Tchobanoglous, G., Theisen, H., and Vigil, S.A; *Integrated Solid Waste Management*: McGraw Hill, New York.
10. UNEP, 2009. *Developing Integrated Solid Waste Management Plan Training Manual*. UNDP, IETC, Okasa, Japan.
11. Wang, L.K., Shammas, N.K. and Hung, Y.T. 2008. *Biosolids Engineering and Management*. Humana Press, Totowa, NJ, USA.
12. Waste Management "*Asian and Pacific Center for Transfer of Technology* (N.D.) India", September 1993.

Journals

Waste Management (Elsevier)
Waste Management & Research (Sage Publications)
Compost Science & Utilizations (Taylor & Francis)
International Journal of Environment and Waste Management (Inderscince, UK)
Journal of Waste Management (Hindwai)
Journal of Material Recycling and Waste Management (Springer)
Journal of Hazardous Materials (Elsevier)
Bioresource Technology (Elsevier)
Waste& Biomass **Valorization** (Springer**)**
Journal of the Air & Waste Management Association

EES – 555: Hazards, Risk Analysis and Management Credits 2(1-1-0)

Unit 1: Earth's Processes and Geological Hazards: Earths processes; concept of residence Time and rates of natural cycles.Catastrophic geological hazards

Unit 2: River flooding: River system & causes of flooding, nature and extent, magnitude and frequency of flooding with special reference to Himalayas. Effects of flooding, response to flood hazards.

Unit 3: Landslide: Common causes of landslides, types of mass movement, slope failure, slope stability, prevention and correction methods.

Unit 4: Earthquakes: Geology of Earthquakes; earthquake quantification; seismic waves, plate boundaries and world's earthquake zones; hazards associated with Earthquakes, response to earthquake hazards; seismic study of Himalayan region.

Unit 5: Volcanism: Nature, extent and causes of volcanism; magma and eruption; volcanic materials; geographic distribution of volcanoes; volcanism and climate.

Unit 6: Chemical Hazards, Hazard Vulnerability Analysis Risk assessment: Introduction, perspectives on Risk, perception of Risk, Hazard identification, Dose response Assessment, Human exposure assessment, Risk Characterization, Risk analysis;

Suggested Readings

Text Books:

1. D. Alexander Natural Disaster, UCL, 1993
2. E. Bryant, Natural Hazard, Cambridge University Press, 1985
3. D. Chapman Natural Hazards, OUP, 1999
4. F.G. Bell Environmental Geology - Principles and Practice, Blackwell Science, 1998
5 Introduction toEnvironmental Engineeringand science (Third editn): Masters & Ela (PHI)

References:
6. K. Smith and R. Ward Floods: Physical Process and Human Impacts, John Wiley and Sons, 1998.
7. V.S.Kale (Ed) Flood Studies in India, Geological Society of India, 1998.
8. Keith Smith Environmental Hazards: Assessing Risk and Reducing Disaster (4th Ed.) Routledge, 2004.
9. A.Vogel, K. Brandes (Ed) Mitigating the Impact of Impending Earthquakes, Spoon Press, 1998.
10. K. Beven and D. Carling Flood: Hydrological, Sedimentological and Geomorphologic Implications, John Wiley and Sons, 1989.

EES-556: Society and Environmental Economics Credits 3 (3-0-0)

Unit 1: Introduction: Introduction – History and theories of organic evolution, Origin of life on earth, Human origin and evolution, Emergence of man , early history and settlements, Social, economic, political and cultural life of man through different ages; **Social Evolution in Man:** Social organization, Individual behavior and society, Social interactions, different modes of interactions; **Society and Social Groups:** Social system, their classification and characteristics, Elements of social system, Functions of social system; **Personality:** Socialization conformity, Social control of conflict, Social stratification and mobility, Caste system, Race and ethnicity, Class system, Estate and status, Class and society; **Integration of Class and Society:** Types of mobility – vertical, horizontal, intergenerational, social ethics;

Unit 2: Man and Environment: Man's role in ecosystem, Evolutionary and ecological parameters in social organization, Theory of social biology, Kind and degree of sociality, social symbiosis; **Population Dynamics:** Population growth, Trends in world and India's population, Social interactions in the population, Stabilization of population; **Biological Rhythms:** Exogenous and endogenous, Organization of animals by biological rhythms, Biological rhythms in uni and multi-cellular organisms; **Mortality and Genetic Diseases:** Acquired and congenital, Autosomal and sex chromosomal abnormalities, Disorders of amino acids and metabolism, Glycogen storage diseases, Hemophilia, Colour blindness, Disorders due to incompatibility of genes; **Social Problems due to Environment:** Industrialization and pollution, Environmental ethics, Role of individual and society in environmental management.

Unit 3: Basics of Economics of Environment: Fundamental concepts in Environmental economics, Economy-environment interaction: Resource Economics, Environment Cost benefit analysis, Circular flow model and Material Balance Model, Environmental Kuznets Curve, Modeling the market process, market equilibrium, consumer surplus and producer surplus. **Renewable Resources and Common Property Resources:** Optimal use of exhaustible and renewable resources, Optimal provision of public goods-Lindahl's equilibrium; Energy and Environment – Resource Scarcity, Pricing of Resources, common property resources

Unit-4: Market Failure and Externalities: Modelling a public good, relationship between public goods and externalities, Absence of property rights: the Coase theorem, **Valuation of Non-marketable goods:** Environmental valuation; Environmental damages/benefits, social cost benefit Analysis,Integrated environmental and Economic accounting and the measurement of environmentally corrected GDP, Use

values, option values and non-use values -total economic value, Valuation techniques; production based, contingent valuation, hedonic-pricing, travel cost,method, risk assessment.

Suggested Readings

Text Books:

1. Botkin, Daniel B. (2011) Environmental Science: Earth as a Living Planet, John Wiley and Sons, New Delhi.
2. Markandya, A. (2006) Environmental Accounting and Sustainability, Edward Elgar Publishing Ltd. U.K.
3. Charles, P. and J.R. Vincent (2003) Natural Resource Accounting and Economic Development: Theory and Practice, Edward Elgar Publishing Ltd. U.K.
4. Haab, T. and Mc Connell K.E. (2003) Valuing Environmental and Natural Resources, Edward Elgar Publishing Ltd. U.K.
5. Harper, C. (1996) Environment and Society, Prentice Hall, Washington D.C.
6. Barry, J. (1999) Environmental and Social theory, Routledge, London.
7. Riley, E. Michelson, W.C. (Ed.) (1998) Hand Book of Environmental Sociology, Westport Greenwood Press, USA.
8. Adame, M.E. (1987) Agricultural Extension in Developing Countries, Longman,

9. Thomas and Callan, (2009). Environmental Economics, Cengage Learning, India Edition
10. Kolstad, C.D. (1999). Environmental Economics, Oxford University Press, New Delhi

Reference Books and Reports

1. Hanley N., J.F. Shogren and B. White (1997). *Environmental Economics in Theory and Practice*, Macmillan.

2. Shankar, U. (Ed.) (2001). *Environmental Economics*, Oxford University Press, New Delhi.

3. World Bank (1993). *The World Development Report, 1993: Investing in Health*, O.U.P., New York

4. Mayerfeld Michael Bell (2012): *An Invitation to Environmental Sociology*, (IV Ed.), Pine Forge Press, SAGE, Landon.

EES 554: Statistics and Computer Applications **Credits 3(2-0-1)**

Unit 1: Attributes and Variables: types of variables, scales of measurement, measurement of Central tendency and Dispersion, Classification and tabulation of data, Graphical representation, Standard error, Moments – measure of Skewness and Kurtosis,

Unit 2: Basic concept of probability theory, Theorem on total and compound probability, Distributions - Normal, log-normal, Binomial, Poisson, t, $\chi^2$and F-distribution.

Unit 3: Tests of hypothesis, significance and confidence limits, t-test, χ^2-test ANOVA: one-way and two-way;. Sampling theory, Statistical design of experiments. Detail study of CRD, RBD, Latin Square design, factorial design, Split plot design

Unit 4: Correlation, Regression, linear, simple and multiple regression models, Approaches to development of environmental models; Computer modeling, Data Analysis using Packages, Statistical Software (such as implementation in R, SPSS)

Suggested Readings:

1. Murray Spiegel, Larry Stephens; Schaum's Outline of Statistics (2014) (Latest edition): McGraw-Hill Education.
2. Peter Dalgaard; Introductory Statistics with R (2008); Sprigner Publication.
3. Michael J. Crawley; Statistics: An Introduction using R (2005), John Wiley & Sons.
4. Irwin Miller, Marylees Miller; John E. Freund's Mathematical Statistics with Applications (2014), Pearson Education.
5. S. C. Gupta, V. K. Kapoor; Fundamentals of Mathematical Statistics (2000), Sultan Chand & Sons.
6. Vic Barnett; Environmental Statistics (2004); John Wiley & Sons.
7. Wayne R Ott; Environmental Statistics and Data Analysis (1995), Lewis Publishers.
8. K. W. Hipel, A. I. McLeod; Time Series Modelling of Water Resources and Environmental Systems (1994); Elsevier.

EES-518: Environmental Toxicology **Credits 3 (2-0-1)**

Unit 1: Introduction: Environmental toxicology as a science – definition and principles, Biological and chemical factors influencing toxicity, inorganic and organictoxicants – entry into Environment, cycles and residence time, Toxicity of pesticides, insecticides, heavy metals, Radioactive minerals, fluorides, chemical fertilizers, etc.,

Unit 2: Assessment and Monitoring of toxicants: Dose-effect and dose response relationships; Principles of toxicity testing, Acute and chronic toxicity, OECD Guideline, test organism, test species selection, bioassays, statistical tests, Methods of toxicity evaluation at cellular and molecular levels by vitro and *in vivo methods*, Monitoring approaches- indicator populations and indicator species, indicators of ecosystem stress, invertebrate microbio tests,

Unit 3: Bio-monitoring and Risk Assessment - Bioconcentration, bioaccumulation and biomagnifications and its impact, impact of toxicants/ pollutants at cellular and molecular level of plants and animals with special reference to human, Sensitivity of ecosystems. Risk assessment - US EPA and other Guideline in risk assessment.

Unit 4: Ecosystem Toxicity: Toxicants and Ecosystems: Toxicants and communities in ecosystems, Multilevel tropic interactions and non- tropic interactions, Functional changes in the Ecosystem, Effect of intersections interactions in the environment, model ecosystems- microcosms and microcosms,

Unit 5: Biosensors, and biomarkers - Concept and approach, advantages, and disadvantages, Molecular marker to toxicants – metabolites as indicators, protein induction, cytochrome P450 enzymes, stress proteins and metallothioneins.

Suggested Readings

1. Newman, M.C. (2012) Quantitative Ecotoxicology, Second Edition, CRC Press, New York.
2. Walker, C.H. (2005).Principles of Ecotoxicology, Fouth Edition, CRC Press, USA.
3. Newman, M.C. (2009) Fundamentals of Ecotoxicology, Third Edition, CRC Press, USA.
4. Johnson, E (2010) Ecotoxicology, Academic Press, New York.
5. Walker, C.H., Sibly, R.M., Hopkin, S. P., Peakall, D.B. (2012). Principles of Ecotoxicology, Fourth Edition, CRC Press.
6. Connell, D.C. (1999). Introduction to Ecotoxicology, Wiley, USA.
7. Calow, P.P. (2009). Handbook of Ecotoxicology, Wiley, USA.
8. Thompson, K.C., Wadhia, K., Loibner, A.P. (2005). Environmental Toxicity Testing, Taylor & Francis, UK.
9. Schüürmann, G., Markert, B.A. (1998). Ecotoxicology: ecological fundamentals, chemical exposure, and biological effects. John Wiley, USA
10. Munawar, M. (1989). Environmental bioassay techniques and their application: proceedings of the 1st international conference held in Lancaster, England, 11-14 July 1988. Kluwer Academic Publishers.
11. Levin, S.A. (1989). Ecotoxicology: problems and approaches, Springer-Verlag.

EES 617: Green Technologies Credits 3 (3-0-0)

1. Introduction, Principles & Concepts of Green Technologies.
2. Historical context: The Greening of Chemistry.
3. Waste: Production, Problems, Prevention.
4. Measuring and Controlling Environmental Performance.
5. Catalysis and Green Chemistry: Introduction, Basics of Organometallic Chemistry & Catalysis, Oxidations and Reductions, C-C Bond Formation.
6. Organic Solvents: Environmentally Benign Solutions (Focus on Water and Ionic Liquids).
7. Organic Solvents: Environmentally Benign Solutions (Focus on fluorous solvents and supercritical CO2).
8. Renewable Resources: What's Available? Chemicals from Biomass.
9. Sustainable Polymers: The Case of Polylactide, Using CO2 and other feed stocks.
10. Green Chemistry and Public Policy.

Text Book

1. Lancaster, M.; Green Chemistry an Introductory Text, Royal Society of Chemistry, Cambridge, UK 2002. ISBM 0-85404-620-8. 2.
2. Cann, M.C.; Connelly, M.E. Real World Cases in Green Chemistry, American Chemical Society: Washington DC. 2000. ISBN 0-8412-3733-6 (Paperback) (RWCGC).
3. Anastas, P. T.; Warner, J. C. *Green Chemistry: Theory and Practice*; Oxford University Press: New York, 1998.

Additional Readings

1. Green Chemistry, RCS Publications.
2. *Chem. Rev.* **2007**, *107*, 2167-2820 (special issue on Green Chemistry).
3. Ahluwalia, V. K. *Green Chemistry: Environmentally Benign Reactions*; CRC Press: BocaRaton, FL, 2008.
4. Ahluwalia, V. K.; Kidwai, M. *New Trends in Green Chemistry*; Kluwer Academic.Dordrecht, The Netherlands, 2004.
5. Anastas, P.; Horvath, I. T. *Chem. Rev.* **2007**, *107*, 2169-2173.
6. Anastas, P. T.; Kirchhoff, M. M. *Acc. Chem. Res.* **2002**, *35*, 686-694.
7. Anastas, P. T.; Warner, J. C. *Green Chemistry: Theory and Practice*; Oxford UniversityPress: New York, 1998.
8. *Renewables-Based Technology: Sustainability Assessment*; Dewulf, J.; Langenhove, H.V., Eds.; John Wiley & Sons, Ltd.: Chichester, UK, 2006.
9. Doble, M.; Kruthiventi, A. K. *Green Chemistry and Engineering*; Elsevier: Burlington,MA, 2007.
10. Manahan, S. E. *Green Chemistry and the Ten Commandments of Sustainability*; ChemChar Research, Inc.: Columbia, Missouri, 2005.

Electives/Optional

ENR 559: Disaster Management **Credits 3 (2-1-0)**

Unit 1: Introduction to Disasters: Concepts and definitions (disaster, hazard, vulnerability, And resilience risks),disaster: classification, causes, impacts(including social, economic, political, environmental, health, psychological, etc.) differential impacts- in terms of caste, class, gender, age location, disability. Global trends in disaster, urban disaster, pandemics, complex emergencies, climate change.

Unit 2 Approaches to Disaster Risk Reduction

Disaster cycle- its analysis, phases, culture of safety, prevention, mitigation and preparedness, community bases DRR, structural- non-structural measures, roles and responsibilities of community, Panchayati Raj Institutions/ urban local bodies (PRIs/ULBs). States, centre, and other stake holders.

Unit 3: Inter-Relationships between Disasters and Development

Factors affecting vulnerabilities, differential impacts, impact of developmental projects such as dams, embankments, changes in landslides, etc. climate change adaptation, relevance of indigenous knowledge, appropriate technology and local recourses.

Unit 4: Disaster Risk Management in India

Hazards and vulnerability profile of India, components of disasters relief: water, food, sanitation, shelter, health, waste management. Institutional arrangements (mitigation, response and preparedness, DM Act and policy, other related policies, plans programmes and legislation) Preparation of onsite and off-site disaster management Plans, Pre-disaster, Actual disaster, Post-disaster relief camp organization, Role of voluntary organizations and Armed Forces, Mitigating natural disasters through preparedness measures.

Unit 5: Community based Disaster Management Post Disaster Survival University/School Disaster Management Disaster Management Act Institutional Arrangement for disaster Management and Mitigation,Technology intervention for disaster Management Disaster Management in Himalayas Incident command system for disaster management Table top simulation exercise for disaster management Case study on forest fire.

Suggested Readings

1. Krynine, D.S. and Judd, W.R. (1998) *Principles of Engineering Geology*, CBS, New Delhi.
2. Smith, K. (1992) *Environmental Hazards,* Routledge, London.
3. Bell, F.G. (1999) *Geological Hazards*, Routledge, London.
4. Bryant, E. (1985) *Natural Hazards*, Cambridge University Press. London.
5. Nagarajan, R. (2001) *Lanslide Disaster – Assessment and Monitoring*, Anmol Publications, New Delhi.
6. Cutter, Susan L. (1999) *Environmental risks and hazards*, Prentice Hall of India, New

EES - 611: Limnology & Chemical Speciation in Aquatic Systems Credits 3(2-0-1)

Unit 1: Definition, scope, and history, types of freshwater bodies lentic, lotic; Physicochemical properties of water; Morphometry and water movement; Light in water; Heat budget of water bodies; Oxygen and

other dissolved gases; Sediments, Sediment-water interface and redox potential; Nitrogen in water; Phosphorus, Sulphur, Calcium and other nutrients; Heavy metals and organic compounds in water;

Unit 2: Life in water: Phytoplankton, periphyton, zooplankton, fish, benthic organisms and Macrophytes; Microbiology of freshwaters; Primary and Secondary production, Production Processes and factors influencing them; Food-chain dynamics and energetic; Detritus and Carbon cycle; Comparative study of lentic and lotic ecosystems;

Unit 3: Estuarine ecosystem; Land-water interactions; Applied Limnology; Water Pollution, Eutrophication; Wastewater treatment, Water quality management and modeling; Aquaculture; Water quality standards; Monitoring water quality; Methods of water and waste-water analysis.

Unit 4: Chemical processes in the aquatic environment with respect to chemical nature of water; sources, pathways and reservoirs of contaminants in aquatic systems.

Unit 5: Heavy metals in aquatic systems, species distribution in non-marine and marine waters and conditions governing them, metal pollution assessment from speciation analysis, (speciation and toxicity of metals).

Unit 6: Coordination compounds, relationship between toxicity and structure, determination of species distribution. Organometallic and organometalloidal compounds, structure-toxicity-relationships, species distribution organic chemicals in aquatic systems, specific groups and their fate in water bodies, prioritisation and hazard assessment of toxic organics, impact on aquatic biota. Analytical methodologies for chemical speciation studies, chemical modeling of aquatic systems. Radionuclides in the aquatic environment, their behavior and bioavailability.

Suggested readings

Text Books:

1. Wetzel, R.G., 2001. Limnology: Lake and River Ecosystems.Third Edition. Academic Press, 1006pp.
2. Dodson, Stanley. 2005. Introduction to Limnology. McGraw Hill. ISBN: 007287935-3 Giller, Paul & Bjorn Malmqvist. 2008. The Biology of Streams and Rivers. Oxford University Press.

ETC 540: Air Pollution and its control **Credits 3 (2-0-1)**

Unit 1: Air pollutants, their sources and harmful effects and on the environment: Meteorology as applied to air pollution and dispersion of air pollutants; Atmospheric physics and air quality; Mobile air pollution sources, Indoor air quality; (Sick building syndrome).

Unit 2: Air quality and emission standards (India and international); Combustion fundamentals (Stoichiometry, thermodynamics, Kinetics);

Unit 3: Aerosols- Stokes law, Brownian motion of aerosol particles, General dynamic Equation for aerosols;

Unit4: Air pollution legislation; Methods for monitoring and control;

Unit 5: Selection of control equipments, Engineering control concepts; Process change, Fuel change, Pollutant removal and disposal of pollutants; control devices and systems (Fabrications, cyclones, Electrostatic precipitation, wet and dry scrubbing, Condensation, flare processes, thermal and catalytic oxidation, other emerging air pollution control devices etc), Removal of dry particulate matter, liquid droplets and mist removal, gaseous pollutants and odor removal. Control of stationary and mobile sources; optimal air pollution control strategies.

Suggested Readings:

1. Introduction toEnvironmental Engineeringand science (Third editn): Masters & Ela (PHI)

2. Atmospheric chemistry and Physics: Seinfeld & Pandis , John wiley & sons

3. Introduction to aerosol science, P C Reist (Macmillan pub)

4. Environmental science, technology, and chemistry: Manahan, S: CRC

5. Chemistry of the upper & Lower Atmosphere: Pitts & pitts. Academic press

EES 619: Water Pollution **Credits 3 (2-0-1)**

Unit 1: Water chemistry and ecological aspects of Water Pollution. Type, sources and consequences of Water Pollution. Surface and ground water., Waste water and its treatment, origins and characteristics of liquid industrial effluents discharged in the water body, chemical and bacteriological sampling and analysis,

Unit 2: Water quality criteria and standards; health effects of Water Pollution; instrumental methods of analysis, for example, AAS, IC, GC, etc., sampling, analysis for pH, EC, turbidity, solids- TDS, acidity, alkalinity, hardness, chloride, salinity, DO, CO2, BOD, COD, Nitrogen, phosphate, sulphate, Cadmium, Microbiological analysis- *E. coli* and its population,

Unit 3: Water pollution control: Pollution due to municipal sewerage dumping, industrial effluent discharge, solid waste dumping – leach ate, infiltration, Assessment of level of pollution, Waste water

treatment: an overview, Water Pollution control and case study; Recent trends in waste water treatment technologies,

Unit 4: Practical: Measurement of pH, EC, turbidity, solids- TDS, acidity, alkalinity, hardness, chloride, salinity, DO, free CO2, BOD, COD, Nitrogen, phosphate, sulphate, Cadmium, *E. coli in various type of water sample*. Field visit for STP/ETP, Chemical analysis of water for ions and cations, metals

Suggested Readings:

1. Introduction toEnvironmental Engineeringand science (Third editn): Masters & Ela (PHI)

2. Trace elements in the Terrestrial Env (D C Adriano) Springer –Verlag)

3. Environmental science, technology, and chemistry: Manahan, S: CRC

4. Waste water Engineering: Metcalf & Eddy., Tata Mcgraw Hill

5. Principles and potential of UASB process: Lettinga G, High Tech

6. Biotechnology and waste water treatment: Foster CF., Cambridge univ press.

EES: 625 Microbial Ecology Credits 3 (2-0-1)

Unit 1: Microbial world- introductory review to the Prokaryotic and Eukaryotic microorganisms, Nutrition and growth, Microbial metabolism and regulation. Major groups of microorganism. Effect of environmental factors on microbial growth; various nutritional forms of microorganisms; microbial colonization, succession and climax;

Unit 2: Natural environments of microorganisms- the terrestrial environment, aquatic environment and extreme environments. Structure, behavior and growth of microorganisms as related to the environment. Types of Interactions-microbe-microbe, Interactions between microorganisms and plants. Interaction between microorganisms and animals.

Unit3: Role of microorganisms in the cycling of bioelements the carbon cycle, nitrogen cycle, sulphur cycle, phosphorous cycle. Role of microorganisms in the degradation of manmade compounds pesticides, synthetic polymers, and other recalcitrant chemicals.

Unit 4: Role of microbes in industries with reference to production of alcohol and organic acid; Antibiotics; Bio-fertilizers; role of microbes in forestry and agriculture. Microorganisms found in food; food spoilage and food poisoning; Fermentation and food preservation;

Suggested Reading:

1.Alexander, M (1979). Advances in Microbial Ecology, Plenum Press.
2.Atlas R. M. and Bartha R (1997) (4th Edition) Microbial Ecology: Fundamental Applications. Benjamin/Cummings Science Pub.

3.Creager, J. G., Black, G and Davidson, V. E (1990). Microbiology: Principles and Applications, Prentice Hall.
4.Mishra, R.R. (1996). Soil Microbiology. CBS Publ.
5.Tate, R. L (1995). Soil Microbiology, John Wiley and Sons Inc.
6.Tortora, G., Berdell, R. R and Case. C. L (1995). Microbiology – An Introduction. The Benjamin/Cumming Publishing Company.

EES 570: Global Climate Change & its Impact Credits 3 (2-1-0)

Unit 1: Climate- past and present, analytical methods of determining long-term changes in Environment – dendroclimatology, tree ring, stable carbon isotope discrimination and stable 180 discrimination for climatological changes.

Unit 2: Future climate scenarios and their impact on crops, ecosystems, animal and human health. Causes of global warming and climate change. Greenhouse gas emission from anthropogenic sources.

Unit 3: CO2 as an important greenhouse gas, global carbon deposits, sinks and sources, effect of elevated CO2 on plant growth, and long-term effect on basic processes and productivity. Carbon sequestration, carbon auditing.
Unit 4: Methane- sources and sinks, methane emission from wetlands. Nitrous oxide- its chemistry, sources and sinks. Nitrous oxide emission from soil. Climate change and impact on horticultural and plantation crops. Ionizing radiations, UV-B, CFC and climate change.

Suggested Readings

Text Books:

1. F. O. Bengtsson Geosphere Biosphere Interaction and Climate, Cambridge University Press, 2001
2. J. Berdowski, R. Guichert and B. Heil The Climate System, A.A. Blakema Publisher, 2000
3. J. T. Hardy, Climate Change: Causes, effects and solutions, John Wiley and Sons, 2003
4. J. Horel and Jack Geisler, Global Environmental Change: An atmospheric perspective, John Wiley and Sons, 1997
5. M. Lal (edtr, Global Warming - Concern for tomorrow, Tata McGraw Hill, 1993

References

1.James I.L, Morison & Michael D. Morecreft (editors), Plant Growth &Climate Changes, BlackwellPublishing, 2006
2. Kendal Mc. Guffie, Climate Modeling, Willey Inter Science, 2003
3. David Archer, Global Warming – understanding the Focus, Willey India Pvt. Limited, 2006
4. Paul C.D. New ton, R. Anfrew Carran, Grant R. Edwards & Pascal A. Nicklas (editors), Agroecosystem
5. Climate Change 2001: Mitigation, Contribution of Working group IV Assessment Report ofInter Governmental Panel on Climate Change, 2007

ES 534: Soil Science &Soil ecology **Credits: 3 (2-0-1)**

Unit1: Composition of Soil; physical, chemical, biological properties. Soil air, water and temperature. Soil organic matter, Nutrient status of soil

Unit 2: Soil fertility and plant growth. Source, characteristics, application of manures, fertilizers. Soil amendment and soil conditioner and their impact on plant growth and development. Micronutrients, their availability.Trace & tracer elements, and their use in uptake translocation and partitioning, metabolic functions of trace elements. Chemistry of adverse soil conditions; Soil pH and liming: acid sulfate soils, soil salinity and alkalinity.

Unit3: Toxic substance in soils. Transformation of nutrient elements in soil crop system, methods for assessment of soil fertility, soil tests and significance of nutrients fractions, efficiency of crop, chelation, coating and organic matter in relation to nutrient availability.

Unit4: Toxicity and deficiency of important elements in soils of Himalayan region and ameliorative measures. Efficiency of nutrient utilization under environmental stress.

Text Books:

1. D. Winegardner *An Introduction to Soil for Environment,* CRC Press, 1996
2. H. Marschner *Mineral Nutrition in Higher Plants*, Academic Press, 1986
3. L. Hirich *et al Soil Chemistry,* John Wiley and Sons, 2001
4. TD Biswas and SK Mukherjee, Tata MCGraw Hill.

References:

1.. Gary M, Pierzynski, J. Thomas, Sims and George F. Vance, Soils and Environmental Quality, 3rd Edition, CRC Press, 2005
2. W. Horst *Plant Nutrition*, Kluwer Academic Publisher, 2001
3 R.W. Miller and R.L. Donahue (edtrs) *Soils in our Environment*, Prentice Hall of India, 2004
4. P.J. Kramer *Adaptation of Plant to Water and High Temperature Stress*, John Wiley and Sons, 1980
5. B.A. Stewart *Advances in Soil Sciences*, Lewis Publisher, *2000*
6. K.H. Head, Manual of Soil Laboratry Testing, 3rd Edition, CRC Press, 2006

ENR: 552 Trees Outside Forest **Credit 3 (2-1-0)**

Unit 1. Introduction to Trees Outside Forests: Agroforestry, Social forestry, Community forestry, Urban forestry, Greenbelt/ Industrial plantations; Community Forest:Definition and concepts, Components and implementation at local and national levels, Social attitudes and community participation, Participation, extension and conflict resolution, Energy plantations, Choice of species, Types of community forests;

Unit 2. Agroforestry Plantations: Basic definition and concepts – advantages and constraints, status of Agroforestry research, classification of Agroforestry systems; Design of Agroforestry plantations – pattern and spacing, diagnosis and design methodology, prospects of GPS/GIS in preparing Agroforestry design; Principles of species selection for Agroforestry – Evaluation of species for the site and Agroforestry design, germplasm sources and provenance variation, concept of multipurpose trees. Management of Agroforestry plantations - genetic improvement of Agroforestry trees, role of biotechnology and other new technologies in Agroforestry, green

manuring - composting, protection from pests, diseases and domestic and wild animals; Extension of Agroforestry technology to farmers – strategies;

Unit 3. Urban and Semi Urban Tree Plantations: Definition and historical background, Art and science of cultivating urban trees, Distribution and ownership, administration, Urban climate and wildlife, Tree architecture, Value of urban and semi urban trees; Urban forest management - special objectives and methods of urban forest planning and management, problems and strategies of urban forest management.

Unit 4.Commercial/ Industrial Forests: Introduction, Species selection, Monoculture vs. Mixed cultures, Sustainability, Productivity and diversity, Management economics, Advantages and threats; Forestry in degraded forest areas and Fringe areas of Protected areas.

Unit 5. Assessment and Measurement of Trees Outside Forests: Challenges and objectives, Methods and tools for inventorying TOFs, Using GIS and remote sensing for spatial and temporal trend analysis, Field inventory, Direct and indirect benefit of TOFs, Economic valuation methods for TOFs, TOFs for rural livelihood; Policy interventions for TOFs in India, International initiatives on the sustainable management of trees outside forests, Case studies from different countries.

Suggested Readings

Text Books:

1. M. P. Singh and D.N. Tewari *Agro-forestry and Waste Land*, Anmol Publication, 1996
2. A. P. Dwivedi, A Test book of Silviculture, International Book Distribution, 1993
3. A.P. Dwivedi, *Agro-forestry - Principles and Practices* Oxford and IHB, 1992
4.Jha, L.K. and Sen Sarma, P.K. (2008) *Agroforestry: Indian Perspectives*, APH publishing corporation, New Delhi.
5. Jha, L.K. (2009) *Advances in Agroforestry*, APH Publication Corporation, New Delhi

References:

1. M. Gadgil and R. Guha, The use and abuse of Nature, Oxford University Press, 2000
2. P. Singh *et al* (edtrs.) *Agro-forestry Systems for Sustainable Land Use*, Science Publisher, 2004
3. P. A. Wojtkowski, Theory and Practices of Agro-forestry Design, Science Publisher, 2004
4.P. A. Wojtkowski, Agrocological Perspectives in Agronomy, Forestry and Agro-forestry, Science Publisher, 2004

EES-621: Environmental Biochemistry and Biophysics Credits 3 (2-0-1)

Unit 1: Introduction: Biochemical degradation of pollutants inside the Cell, Cellular interactions with pollutants, Pollutant interactions with biological systems at different levels – organism, organ and cell organelles**;** Bioconversion of Pollutants**:** active vs. inactive process, Enzymic conversion degradation by monooxygenesis, Role of Cytochrome P 450 and its multiple form;

Unit 2:Metal Toxicity: Chemical form, metal biomacromolecule interaction, teratogenerity and carcinogenicity; Cellular/Tissue Injury**:** Altered membrane permeability, Free radical formation, Lipid peroxidation, Lysosomal degradation, Superoxide dismutase, Environmental stimuli and Cellular signaling.

Unit 3: Cell: Cellular function of cell, Membrane structure and transport origin and conduction of impulse in nerve cell muscles, Methods in bioelectric measurements**;** Radiation and molecular response: Elementary aspects of atomic and molecular excitation, Biointeractions with environment,

Unit 4: Fundamental and applied aspects of extremely low frequency, radio and microwave fields, Bioacoustics, Biomedical aspects of laser; Magnetic environments and geomagnetic fields: Behavioral changes, therapeutic and diagnostic possibilities.

Suggested Readings

Text Books:

1. *J. Levitt Responses of Plants to Environmental Stress, Academic Press,1987*
2. *A. Lehninger Biochemistry, Kalyani Publishers,1993*
3. G. Guyot Atmospheric Physics and Climatology, John Wiley and Sons, 1997
4. A.H.Sobel The Global Circulation of the Atmosphere, Princeton 2007
5. J. Monteith, M. Unsworth, Principles of Environmental Physics, Elesevier, 2007

References:

1 Roberto Pintan, Zeno Varanini, Paolo Nannipieri (editors), The Rhizosphere-Biochemistry and Organic Substances at the Soil Plant interface 2nd Edition, CRCPress, 2007
2. D. Voet and J. Voet Biochemistry, John Wiley and Sons, 2004
3. R. Roger Hand Book of Plant Ecophysiology Techniques, Kluwer, 2001
4. C. Smith, Environmental Physics, Routledge Publisher, 2001
5. C.W. Rose, An Introduction to Environmental Physics of Soil, Water and Watershead,Cambridge University Press, 2009
6. A.C. Lasaga Kinetic Theory in the Earth Sciences, Princeton 2000

ENR 515: Integrated Watershed Management Credit 3 (2-1-0)

Unit 1: Introduction: Hydrologic cycle, Inventory of earth's water; **Precipitation:** Various forms of precipitation, interpretation of precipitation data; Evaporation **and Evapo transpiration:** Meteorological factors, transpiration, methods of estimating evaporation from land surface using Penman's equation;

Unit 2:Infiltration and percolation: Infiltration capacity of soil, Factors influencing infiltration capacity, Methods of determining infiltration capacity; **Runoff:** Duration of runoff, Flow rating curves – their determination, adjustment and extension, Catchments characteristics and their effects of runoff, Climatic factors; **Ground Water:** Factors influencing occurrence of ground water, Ground water flow, Obstruction of groundwater;

Unit 3:Hydrological forecasting: Frequency analysis, Probability of N-year events, Probability plotting, Cyclic nature of hydrological phenomena; **Hydrological Cycle in Watershed:** Properties of

hydrological cycle, Water balance – estimation, importance in watershed development, Land in watershed – geomorphology, soil survey soil erosion, soil loss equation, methods to control soil erosion; Biotic elements – vegetation patterns land use patterns, land capability, Effects of humans and livestock; Socioeconomic factors – societal commitments and interventions, demographic profile, land tenure system and property rights, resource access and equity, Water conservation and rainwater harvesting;

Unit 4: Watershed Management: Concepts and framework of watershed development and management, Elements of integrated watershed management, Criteria for prioritizing watershed for development, Prioritization of projects and programmes; Monitoring and evaluation of projects and programmes; Socio-economic –institutional elements and challenges of watershed management; Integrated approach – challenges faced by resource managers.

Suggested Reading:

1. Hydrology and the Management of Watersheds by Kenneth N. Brooks Peter F. Ffolliott Joseph A. Magner, John Wiley & Sons, Inc.
2. Integrated Watershed Management: Principles and Practice by Isobel W. Heathcote, John Wiley & Sons.
3. Watershed Management Guidebook by Kevin Drake and Michael Hogan, A Publication by Integrated Environmental Restoration Services, Inc.

EES 612: Science of Climate Change Credits 3(3-0-0)

Unit 1: The Climate System: Structure and composition of earth's atmosphere, Energy budget of earth's atmosphere, General circulation, Horizontal and vertical energy transfers; other components of climate system viz., oceans, cryosphere, biosphere and geosphere and their interrelationship;

Unit 2: Science of Climate Change:Greenhouse effect, Greenhouse gases, and their sources and sinks, Clouds, Aerosols and Ozone layer and greenhouse effect, Radiative forcings and Global warming potential, Natural causes of climate change, Past climate changes, Anthropogenic activities and rising concentration of GHGs in the atmosphere; Study of Climate Change:Climate construction using instrumental records, Palio-climatic analysis using proxy data, Climate simulation through modeling, climate change projections from different models, Uncertainties in climate change projections;

Unit 3: Impact of Climate Change: Sea level rise – vulnerability of coastal areas and island states, Diminishing water resources, Glacier retreat, Agriculture, Forestry, Biodiversity, Human health, Infrastructure and Industry, Extreme events, Case studies from India and South Asia;

Unit 4: Policy Responses to Climate Change:IPCC, its establishment, purpose, organization and climate change projections, UNFCCC, its evolution, objectives, highlights of various articles, Indian negotiating stance, Developing country commitments under the UNFCCC, Existing policies and legal framework, Enabling activities such as ALGAS and reporting requirements e.g. NATCOM;

Unit 5: Approaches and Programmes Responding to Climate Change:Clean and energy efficient technologies for climate change mitigation, Climate change mitigation programmes – Indian initiatives, Forests and carbon sequestration, LULUCF, CO_2 sequestration opportunities in India, Adapting to climate change, Integration of

traditional wisdom with climate change adaptation, Case studies, Adaptation and sustainable development linkages, Linking climate change mitigation and adaptation; Linkages of UNFCCC with other International Conventions:CBD, CCD, Ramsar Convention, MDG.

ETC 510: Water & Waste Water Engineering Credits 3 (3-0-0)

Unit-I Characteristics of water: Physical, chemical and biological standards. Wastewater treatment concepts; pretreatment, primary treatment, secondary treatment, tertiary treatment. Adsorption, Ion-exchange, Membrane processes. Water quality standards.

Unit-II Theory and design of physicochemical unit operations, screening, grit, removal equalization, sedimentation. Filtration: Slow and rapid gravity filter, multi-media filters and pressure filters. Design of slow sand filter and rapid sand filter. Disinfection: theory and application of chlorine. Miscellaneous methods of water treatment- removal of iron and manganese, hardness, fluorides, colour, taste and odour, dissolved metals and gases.

Unit-III Aerobic unit operations for organic carbon removal such as activated sludge, trickling filter, oxidation ditch, oxidations ponds, aerated lagoons, root zone treatment, vermifilter etc. Anaerobic operations for organic carbon removal such as UASB, filters, fluidized/expanded bed systems etc. Biological unit operations for nitrogen and phosphorus removal.

Unit-IV Tricking filters classification, Design parameters, NRC formula, Recirculation in tricking filter merits and demerits, Operation problem encountered in tricking filters and Corresponding remedial measures. Design problems, Theory and Design of Rotatory biological contactors**.**

Unit-V Theory and design of Sludge treatment, sludge thickening, sludge drying, sludge thickening, Sludge conditioning, incineration, aerobic and anaerobic digestion of sludges. Theory and design of wastewater disposal and systems; disposal to inland water bodies, sea/ocean disposal; land/underground disposal.

Suggested readings

1. Metcalf and Eddy (2003) *Wastewater Engineering: Treatment and Reuse*, (4th Edition), Tata McGraw-Hills Comp. Inc., New York.
2. Qasim, S.R., Motley, E.M., Zhu, G. (2000) *Water Works Engineering: Planning Design and Operation*, Prentice Hall, New Jersey.
3. Birde, G.S., Birde, J.S. (2004) *Water Supply and sanitary Engineering*, 7th Ed., Dhanpat Rai Publishing, New Delhi.

4. Viessman, W., Hammer, M.J., Perez, E.M., Chadik, P.A. (2009) *Water supply and pollution Control*, PHI learning Pvt. Ltd., New Delhi.
5. Hammer, M.J., Hammer, M.J. Jr. (2008) *Water and wastewater Technology*. 6th Ed. PHI learning Pvt. Ltd., New Delhi.
6. Punmia, B.C., Jain, A. (2005) *Environmental Engineering.* Laksmi Pub. Pvt. Ltd, New Delhi.
7. Davis, M. (2010) *Water and Wastewater Engineering*. McGraw Hills, New York.
8. Fair, Geyer,Okun's Water and Wastewater Engineering: Water Supply and Wastewater Removal (2010) (3rd Edition). John Wiley and Sons, New York.

Journals

Water Research - Elsevier
Water Science & Technology - IWA
Chemosphere - Elsevier
Bioresource Technology – Elsevier
Chemical Engineering Journal – Elsevier
Desalination and Water Treatment
Chemical Engineering Sciences
Biochemical Engineering Journal
Journal of the Taiwan Institute of Chemical Engineers
Process Biochemistry
International Biodeterioration and Biodegradation
Journal of Environmental Chemical Engineering

ETC-530 Solid& Hazardous Waste Management Credits 3 (From M.Tech)

Unit I: Introduction: Solid waste- Sources and types of solid wastes factors affecting the generation rates. Municipal solid waste (MSW)**:** physical and chemical composition, factors affecting MSW quality and quantity, hierarchy of waste management, RCRA, integrated solid waste management. Overview of solid waste generation and management practices in India. Hazardous wastes, types, sources, composition and classification. Legal framework for handling and storage of municipal, medical and hazards wastes in India.

Unit II: Waste Storage, Collection and transportation, Storage- movable bins, fixed bins. MSW Collection system, Container system, stationary container system, Transfer and transport, processing, waste transportation system, waste, separators, size reduction equipments, screening equipment, Material recovery facility. Hazardous wastes storage- onsite and offsite storage, hazardous waste transportation, International trade/export/ import of hazards waste, Basel Convention, Electronic waste – storage and treatment options. Waste disposal system and health and pollution issues.

Unit III: Waste recycling and waste -to–energy concept: role of formal and informal sector, resource derived fuels (RDF)- concept, processing, application and limitations, waste-to-energy, concept, waste calorific value assessment, sources, Thermal conversion technologies: incineration, gasification, pyrolysis, biogas, fuel from wastes and char; limitation and health issues. Composting and vermicomposting: types, process description, design and operational consideration of aerobic and anaerobic composting, process description.

Unit IV: Hazardous waste treatment methods: criteria for treatment selection, land disposal, combustion, solidification. Sanitary Landfill Technology: Landfilling, site selection criteria, landfill layout, landfill sections, occurrence of gases and, leachate in landfills: composition and characteristics, operation control, waste decomposition phases in sanitary landfill, gas control and utilization, flaring system. Bioreactor landfill- types and operation management, Post closure operations in landfill.

Unit V: Incinerator technology: concept, engineering and applications, types of incinerators, mass incinerator system for MSW, thermal processing system, different units of a typical incinerator, unit operations, fuel gas controlling, air pollution control in incineration, residual management, legal, political and social issues with incineration technology, medical waste treatment, residues management in hazardous waste treatment, Technical issues and solutions in mass incinerators, ecosystem health and occupational issues in incinerator.

Suggested Readings

1. EPA (1995). Decision-Makers' Guide to Solid Waste Management, Vol-I & II. US EPA, Washington, D.C.
2. FAO (2003). On-farm Composting Methods. FAO, Rome.
3. Guidelines for Management and Handling of Hazardous wastes MOEF (1991), Govt. of India.

4. Kaily, G. (1997). Environmental Engineering. The McGraw-Hill Companies, New York, NY.
5. Liu, D.H.F., and Liptak, (2000). B.G. Hazardous Waste and Solid Waste, Lewis Publishers, Boca raton, FL.
6. Pichetel, J. (2005). Waste management Practices – Municipal, Hazardous, and Industrial. Taylor and Francis, Boca Raton, USA. 659 pp.
7. Reinhart, D.R., and Townsend, T.G. (1997). Landfill Bioreactor Design and Operations. Lewis Publishers, New York, NY.
8. Tchobanoglous, G., and Kreith, F. (2002). Handbook of Solid Waste Management. McGraw Hill, New York.
9. Tchobanoglous, G., Theisen, H., and Vigil, S.A; Integrated Solid Waste Management: McGraw Hill, New York.
10. UNEP (2009). Developing Integrated Solid Waste Management Plan Training Manual. UNDP, IETC, Okasa, Japan.
11. Wang, L.K., Shammas, N.K. and Hung, Y.T. (2008). Biosolids Engineering and Management. Humana Press, Totowa, NJ, USA.
12. Waste Management (1993). Asian and Pacific Center for Transfer of Technology (N.D.) India. September.

Journals

Waste Management - Elsevier
Waste Management & Research -Sage
Compost Science & Utilizations - Taylor & Francis
International Journal of Environment and Waste Management - Inderscince, UK
Journal of Waste Management - Hindwai
Journal of Material Recycling and Waste Management - Springer
Journal of Hazardous Materials - Elsevier
Bioresource Technology - Elsevier
Waste& Biomass *Valorization* - Springer
Journal of the Air & Waste Management Association - AWMA, USA

EES 612: Science of Climate Change **Credits 3 (2-1-0)**

Unit 1: The Climate System and its Components: *Atmosphere*: **C**omposition of earth's atmosphere, General circulation, Horizontal and vertical energy transfers; Oceans: Composition and properties, oceanic circulation, temperature and salinity;Cryosphere: components and properties of cryosphere; biosphere and geosphere and their interrelationship;

Unit 2: Science of Climate Change: Energy budget of earth's atmosphere, Greenhouse effect, Greenhouse gases, their sources and sinks, Clouds, Aerosols and Ozone layer and greenhouse effect, Radiative forcings and Global warming potential, Optical Depth of GHGs and aerosols, Natural causes of climate change, Anthropogenic activities rising of GHGs concentration in the atmosphere and its impact on Global surface temperature, Energy Balance Climate Model (EBCM), Hydrological cycle, carbon cycle

Unit 3 : **Modelling of Climate System**: What is a climate Model?, Types of Models, Intermediate complexity models, General Circulation Models, Components of a climate model : atmosphere, ocean, sea-ice, land-surface, marine biogeochemistry, Ice sheets, Coupling between the components; Numerical resolution of the equations: Consistence, convergence and stability, Time and space discretisations using finite differences, spectral representation and finite element methods; Testing and validation of models.

Unit 4 : **The response of climate system to a perturbation** : Climate forcing and climate response : Notion of radiative forcing, major radiative forcing, equilibrium response of the climate system – a definition of feedback; Direct physical feedbacks : Water vapour feedback and lapse rate feedback, Cloud feedback, Cryospheric feedback; Geochemical, biogeochemical feedback : the carbonate compensation, interaction between plate tectonics, climate and the carbon cycle, Interactions between climate and terrestrial biosphere.

Unit 5: Impact, Future Climate changes and policy response:IPCC and climate change projections**,**Future climate changes, Emission scenarios, RCPs, climate projections for the 21st century, Long term climate changes, Impact of Climate Change: Sea level rise – vulnerability of coastal areas and island states, Diminishing water resources, Glacier retreat, Agriculture, Forestry, Biodiversity, Humanhealth, Infrastructure and Industry,

Suggested Readings:

1. Introduction to Climate System Dynamics and Modelling: H. Goose, P. Y. Barriat, W. Lefebvre, M. F. Loutre, V. Zunz.
2. A Climate Modelling Primer: K. McGuffie, A. Henderson-Sellers.
3. Climate Modelling for Scientists and Engineers: MATLAB Exercises; John B. Drake.
4. IPCC – WG1 Report: Summary for Policy Makers – Physical Science Basis.
   IPCC – WG1 Report: Detailed Technical Report.

EES-752: Environmental Modeling **Credits 3 (2-0-1)**

Unit 1: Introduction: Role of Modeling in Environmental Science. Model Classification- Deterministic Models, Stochastic Models, Dynamic Models, Steady State Models. Mass balance - Continuity equation, Energy balance – Thermodynamic energy equations.

Unit 2:Air Quality Modeling: Model classification, Eulerian and Lagrangian Model, Gaussian dispersion model, Dispersion parameters, Plume rise, Removal mechanisms, Long and short term dispersion models, Receptor Model: Chemical Mass Balance Model, Introduction to Chemical Transport Modelling, Case studies and Model applications;

Unit 3:Water Quality Modeling: River hydrology, surface water pollutants, Physical laws and their use in modeling; Surface Water Quality Modeling: water quality in rivers, estuaries and lakes, measurements and evaluation of DO and BOD in rivers, Eutrophication process and basic mechanisms and its significance in surface water; Water Quality Model Equations**:** Model set-up, calibration, and validation procedures, selection, Case studies, Application of water quality model; Oxygen Sag Model.

Unit 4: Ecological Modelling: Microbial Growth Kinetics- Exponential Growth Model, Logistic Growth Model, Monod Equation, Stochastic birth and death processes, Discrete time models, Two Species Population Growth Model of Competition. Lotka-Volterra Prey-Predator Model.

Text Book:

1. Introduction to Environmental Science & Engineering: Gilbert M. Masters, Pearson Education.

Reference Books:

2. Fundamentals of Atmospheric Modelling: Mark Z. Jacobson, Cambridge University Press.
3. Air Pollution Modelling: Paolo Zannetti, WIT Press.
4. Surface Water Quality Modelling: Steven C. Chapra, Waveland Press.
5. An Introduction to Mathematical Models in Ecology and Evolution: Michael Gillman, Wiley-Blackwell.

EES: Atmospheric Modelling **Credit: 3 (2-0-1)**

Unit 1. Atmospheric Structure, composition and thermodynamics: Pressure, density, and composition, Temperature structure, Equation of state, Change of pressure with altitude, Water in the atmosphere, First law of thermodynamics, Continuity equations for air, gas and particle, Thermodynamic energy equations.

Unit 2. Momentum equations in Cartesian and spherical coordinate: Local acceleration, Coriolis force, Gravitational force, Pressure Gradient Force, Viscous force, Turbulent flux divergence, Complete Momentum equation, Application of the momentum equations: Geostrophic wind, gradient wind, Surface-layer wind, surface winds around highs and lows

Unit 3. Hydrostatic and nonhydrostatic models, Vertical coordinate conversions, Altitude coordinate, Pressure coordinate, Sigma-pressure coordinate, Numerical solutions to partial differential equations: operator splitting, Advection-diffusion equations, Finite-difference approximations, Advection schemes used in air-quality models.

Unit 4. Boundary layer and surface processes: Turbulent fluxes of momentum, energy, and moisture, Friction wind speed, Surface roughness lengths, Parameterization of kinematic turbulent fluxes, Eddy diffusion above surface layer, Ground surface temperature and soil moisture.

Unit 5. Model design, application and testing: Determining scales of interest, dimension of the model, selecting processes, variables, computer architecture, coding and optimizing the model, Time steps and intervals, Initial conditions, Boundary conditions, Input and ambient data, Simulations and Sensitivity tests; Example Model Simulations.

Suggested Readings:

1. Fundamentals of Atmospheric Modelling: Mark Z. Jacobson.
2. Atmospheric Modelling, Data Assimilation and Predictability: E. Kalnay.
3. Fundamentals of Numerical Weather Prediction: Jean Coiffieer.