SYLLABUS FOR UNDER GRADUATE COURSE IN Environmental Science (Bachelor of Science Examination)

UNDER

CHOICE BASED CREDIT SYSTEM

Course structure of UG Environmental Science Honours

Semester	Course	Course Name	Credits	Total marks
I	AEC-I	MIL(Odia) / English	04	100
	C-I	Earth and earth surface processes	04	75
	C-I Practical		02	25
	C-II	Physics and chemistry of environment	04	75
	C-II Practical		02	25
	GE-I	GE-I	06	100
			22	
II	AEC-II	Environmental Science	04	100
	C-III	Water and water resources	04	75
	C-III Practical		02	25
	C-IV	Land and soil conservation and management	04	75
	C-IV Practical		02	25
	GE-II	GE-II	06	100
			22	
III	C-V	Ecology and ecosystems	04	75
	C-V Practical		02	25
	C-VI	Environmental biotechnology	04	75
	C-VI Practical		02	25
	C-VII	Atmosphere and global climate change	04	75
	C-VII Practical		02	25
	GE-III	GE-III	06	100
	SEC-I	SEC-I	04	100
			28	
IV	C-VIII	Systematics and biogeography	04	75
	C-VIII Practical		02	25
	C-IX	Urban ecosystems	04	75
	C-IX Practical		02	25
	C-X	Environmental legislation and	06	100

		policy		
	GE-IV	GE-IV (Theory)	04	75
	GE-IV Practical	GE-IV (Practical/Tutorial)	02	25
	SEC-II	SEC-II	04	100
			28	
Semester	Course	Course Name	Credits	Total marks
V	C-XI	Biodiversity and conservation	04	75
	C-XI Practical		02	25
	C-XII	Organismal and evolutionary biology	04	75
	C-XII Practical		02	25
	DSE-I	Energy and environment	06	100
	DSE-II	Environmental Economics (Practical/Tutorial)	04	75
	DSE-II Practical		02	25
			24	
VI	C-XIII	Environmental pollution and human health	04	75
	C-XIII Practical		02	25
	C-XIV	Natural resource management and sustainability	06	100
	DSE-III	Natural Hazards and Disaster Management	04	75
	DSE-III Practical		02	25
	DSE-IV	Solid waste management	04	75
	DSE-IV Practical		02	25
	OR			
	DSE-IV	Dissertation	06	100*
			24	

Discipline Specific Elective Papers: (Credit: 06 each) (4 papers to be selected by students of Environmental Science Honours): DSE 1-IV

1. Energy and environment
2. Environmental economics
3. Natural hazards and disaster management
4. Solid waste management

5. *Dissertation on Solid waste management (can be opted as alternative of DSE-IV only and of 6 credits. **Dissertation content: 50, Seminar: 30, Viva Voce: 20)**

ENVIRONMENTAL SCIENCE HONOURS

HONOURS PAPERS:

Core Paper – 14 papers
Discipline Specific Elective – 4 papers
Generic Elective for non Environmental Science students – 4 papers. Incase University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper.

Marks per paper – Mid term : 20 marks, End term : 80 marks, Total – 100 marks
Credit per paper – 6
Teaching hours per paper – 50 hours + 10 hours tutorial

Core Paper I

EARTH AND EARTH SURFACE PROCESSES

Introduction: The paper introduces students to the basic structure and composition of the Earth and will explore various surface processes and their impact on and role in living systems. It will also deal with the interactive processes in the inner as well as outer Earth's surface.

UNIT 1: Origin of Earth and System processes

Solar system formation and planetary differentiation; formation of the Earth: formation and composition of core, mantle, crust; chemical composition of Earth; geological time scale and major changes on the Earth's surface; Holocene and the emergence of humans. Concept of plate tectonics and continental drift theory, continental collision and formation of the Himalaya; ocean floor spreading; mantle convection and, major plates; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; paleontological evidences of plate tectonics.

UNIT 2: Minerals and rocks

Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; agents of erosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by running water, wind and glaciers.

UNIT 3: Earth surface processes

Atmosphere: evolution of earth's atmosphere, composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface; land surface processes: fluvial and glacial processes, rivers and geomorphology; types of glaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastal processes.

UNIT 4: Importance of being a mountain

Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; development of glaciers, perennial river systems and evolution of monsoon in Indian subcontinent; formation of Indo-Gangetic Plains, arrival of humans; evolution of Indus Valley civilization; progression of agriculture in the Indian subcontinent in Holocene; withdrawing monsoon and lessons to draw.

Practicals: Based on the theory/ fieldwork.

Text Books:

- Keller, E.A. 2011. *Introduction to Environmental Geology* (5th edition). Pearson Prentice Hall.
- Krishnan, M. S. 1982. *Geology of India and Burma*. CBS Publishers & Distributors.

Reference Books:

- Bridge, J. & Demicco, R. 2008. *Earth Surface Processes, Landforms and Sediment deposits*. Cambridge University Press.
- Duff, P. M. D. and Duff, D. (Eds.). 1993. *Holmes' Principles of Physical Geology*. Taylor & Francis.
- Gupta, A. K., Anderson, D. M., & Overpeck, J. T. 2003. Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. *Nature* 421: 354-357.
- Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. *Current Science* 90: 1082-1090.
- Leeder, M., & Arlucea, M.P. 2005. *Physical Processes in Earth and Environmental Sciences.*Blackwell Publishing.
- Pelletier, J. D. 2008. *Quantitative Modeling of Earth Surface Processes* (Vol. 304). Cambridge: Cambridge University Press. Chicago.

CORE PAPER II

PHYSICS AND CHEMISTRY OF ENVIRONMENT

Introduction: This paper aims to build on conceptual understanding of students by exposing them to the basic principles behind various environmental processes. The paper has been divided into two sections, with the view to introduce students to the concepts of physics and chemistry associated with particle movement, chemical processes and pollutant chemistry.

UNIT 1: Fundamentals of environmental physics

Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency), black body radiation, Kirchhoff's law, Stephan-Boltzmann equation, Wein's Displacement law, spectro-photometric concepts: absorption and transmission of light, Beer–Lambert law, scattering of light, Rayleigh and Mie scattering; photoelectric effect and solar photovoltaic cells. Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force).

UNIT 2: Movement of pollutants in environment

Concepts of diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, hydraulic potential, Darcy's equation, types of flow, turbulence. Concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); mixing heights, laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power, efficiency of turbines, wind mills and hydroelectric power plants.

UNIT 3: Fundamentals of environmental chemistry

Atomic structure, electronic configuration, periodic properties of elements; types of chemical bonds; mole concept, molarity and normality; quantitative volumetric analysis.
Thermodynamic systems; acid-base theories and salts, solubility products; redox reactions; concepts of pH and pE, concept of buffer, Henderson-Hasselbalch equation; electrochemistry, Nernst equation, electrochemical cells. Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, polarity of the functional groups, synthesis of xenobiotic compounds like pesticides and dyes, synthetic polymers.

UNIT 4: Air, Water and Soil chemistry

Structure and composition of atmosphere; photochemical reactions in atmosphere; smog: classical smog and photochemical smog, aerosols: PM 10, PM 2.5; chemistry of acid rain, case studies; ozone chemistry and ozone layer depletion, role of CFCs in ozone depletion. Physico-chemical properties of water; alkalinity and acidity of water, hardness of water, solubility of gases in water, metal complex formation and chelation; heavy metals in water. Soil composition;

relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation exchange reactions in soil; NPK in soil.

Practicals: Based on the theory.

Text Books:

- Forinash, K. 2010. *Foundation of Environmental Physics*. Island Press.
- Pani, B. 2007. *Textbook of Environmental Chemistry*. IK international Publishing House.

Reference Books:

- Beard, J.M. 2013. *Environmental Chemistry in Society* (2nd edition). CRC Press.
- Boeker, E. & Grondelle, R. 2011. *Environmental Physics: Sustainable Energy and Climate Change*. Wiley.
- Connell, D.W. 2005. *Basic Concepts of Environmental Chemistry* (2nd edition). CRC Press.
- Girard, J. 2013. *Principles of Environmental Chemistry* (3rd edition). Jones & Bartlett.
- Harnung, S.E. & Johnson, M.S. 2012. *Chemistry and the Environment*. Cambridge University Press.
- Hites, R.A. 2012. *Elements of Environmental Chemistry* (2nd edition). Wiley & Sons.
- Manhan, S. E. 2000. *Fundamentals of Environmental Chemistry*. CRC Press.

CORE PAPER III

WATER AND WATER RESOURCES

Introduction: The paper introduces students to the hydrological cycle, properties of water, physicochemical and biological water quality assessment and indices, types of water resources, their use and management. It will also highlight the problems associated with water shortages in India and familiarizes students with case studies on international and national conflicts on water.

UNIT 1: Properties of water

Physical: temperature, colour, odour, total dissolved solids and total suspended solids; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapo-transpiration; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes.

UNIT 2: Surface and subsurface water

Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of water; formation and properties of aquifers; techniques for ground

water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management; rain water harvesting in urban settings.

Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine ecosystem and resource management (planning approach, construction techniques and monitoring of coastal zones).

UNIT 3: Wetlands and their management

Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India, National River linking plan: ecological and economic impacts.

UNIT 4: Water resources, conflicts, laws and treaties

Water resources (oceans, rivers, lakes and wetlands) and types of water; Overexploitation of surface and ground water resources; water quality standards in India; role of state in water resources management
Water resources and conflicts on its sharing, case studies on Kaveri and Krishna river water disputes; Multipurpose river valley projects in India and their environmental and social impacts; case studies of dams - Narmada and Tehri dam issues; International agreements to resolve these conflicts. Water Act 1974; Ganges water treaty; Teesta water treaty.

Practicals: Based on the theory.

Text Books:

- Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-Hill Publications.

Reference Books:

- Bansil, P.C. 2004. *Water Management in India*. Concept Publishing Company, India.
- Brebbia, C.A. 2013. *Water Resources Management VII*. WIT Press.
- CEA. 2011. *Water Resources and Power Maps of India*. Central Board of Irrigation & Power.
- Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. *Science* **339**: 36- 37.
- Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. *Water Resource Systems Planning and Analysis*. Englewood Cliffs, NJ, Prentice Hall.
- Schward& Zhang, 2003. *Fundamentals of Groundwater*. John Willey and Sons.
- Souvorov, A.V. 1999. *Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management*. Elsevier Publications.
- Vickers, A. 2001. *Handbook of Water Use and Conservation*. WaterPlow Press.

CORE PAPER IV

LAND AND SOIL CONSERVATION AND MANAGEMENT

Introduction: This paper introduces students to the fundamentals of land and soil degradation. Each unit covers a range of topics, which will help students develop basic understanding of properties of soil and how the quality of land and soil degrades due to anthropogenic activities.

UNIT 1: Fundamentals of soil science

Land as a resource, ecological and economic importance of soil; Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity; soil taxonomy maps.

UNIT 2: Soil degradation - causes

Types and causes of soil degradation; Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, impact soil degradation on agriculture and food security; industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.

UNIT 3: Land use changes and land degradation

Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economic and institutional factors; drivers of land use and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats.

UNIT 4: Land degradation and its control

Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries Sustainable land use planning; role of databases and data analysis in land use planning control and management; land tenure and land policy; legal, institutional and sociological factors; integrating land degradation assessment into conservation.

Practicals: Based on the theory/fieldwork.

Text Books:

- Brady, N.C. & Well, R.R. 2007.*The Nature and Properties of Soils* (13th edition), Pearson Education Inc.

Reference Books:

- Gadgil, M. 1993. Biodiversity and India's degraded lands. *Ambio* **22:** 167-172.
- Johnson, D.L. 2006. *Land Degradation* (2nd edition). Rowman & Littlefield Publishers.
- Marsh, W. M. & Dozier,J. 1983. *Landscape Planning: Environmental Applications*. John Wiley and Sons.
- Oldeman, L. R. 1994. The global extent of soil degradation. *Soil resilience and sustainable land use*, *9*. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
- Pandit, M.K. et. al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. *Biodiversity Conservation* **16**: 153-163.
- Pandit, M.K. &Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. *Conservation Biology: Voices from the Tropics.* pp. 123-133. Wiley-Blackwell, Oxford, UK (file:///Users/mkpandit/Downloads/Raven%20et%20al.%202013.%20CB%20Voices %20from %20Tropics%20(2).pdf) .
- Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. *Conservation Biology* 17: 358-366.
- Scherr, S. J. 1999. *Soil degradation: A threat to developing-country food security by 2020?* (Vol. 27). International Food Policy Research Institute.

CORE PAPER V

ECOLOGY AND ECOSYSTEMS

Introduction: This paper will introduce to the students the basic understanding of ecosystem and its structural and functional aspects. It will explore the interconnectedness among all the biotic and abiotic components of environment and the dynamic nature of the ecological processes in maintaining equilibrium in nature.

UNIT 1: General concepts of Ecology

Basic concepts and definitions: ecology, ecosystems, resistance and resilience; autecology; synecology; major terrestrial biomes, Biogeochemical cycles and sedimentary cycle, role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; thermoregulation; strategies of adaptation in plants and animals.

UNIT 2: Ecology of populations

Concept of population and meta-population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth; deterministic and stochastic models of population dynamics; rudreal, competitive and stress-tolerance strategies.

UNIT 3: Ecology of communities

Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: primary and secondary successions, models and types of successions, climax community concepts, examples of succession. ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche;, impacts of biological invasion on ecosystem and communities, case studies.

UNIT 4: Ecosystem ecology

Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; ecosystem boundary; ecosystem function; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy, ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake.

Practicals: Based on the theory.

Text Books:

- Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Sounders.

Reference Books:

- Groom. B. & Jenkins. M. 2000.*Global Biodiversity: Earth's Living Resources in the 21st Century.* World Conservation Press, Cambridge, UK.
- Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. *The Ecology of Plants*. Sinauer associates incorporated.
- Loreau, M. & Inchausti, P. 2002. *Biodiversity and Ecosystem functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.
- Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. *New Phytologist* 203: 697-703.

- Pimentel, D. (Ed.). 2011. *Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species*. CRC Press.
- Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications.
- Wilson, E. O. 1985. The Biological Diversity Crisis. *BioScience* 35: 700-706.

CORE PAPER VI

ENVIRONMENTAL BIOTECHNOLOGY

Introduction: This paper presents an objective view of the application of biotechnological know-hows in tackling environmental problems. It starts with basic knowledge about molecular biology and later links to application-based processes and techniques.

UNIT 1: Structure and Function of DNA, RNA and Protein

DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra, denaturation and renaturation kinetics; biological significance of different forms; Synthesis. RNA: structural forms and their characteristics. Protein: hierarchical structure, types of amino acids; posttranslational modifications and their significance; synthesis; types and their role: structural, functional (enzymes). Central dogma of biology; genetic material prokaryotes, viruses, eukaryotes and organelles; mobile DNA; chromosomal organization (euchromatin, heterochromatin - constitutive and facultative heterochromatin).

UNIT 2: Recombinant DNA Technology

Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, transferase, reverse transcriptase), other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotide kinase); genomic and cDNA libraries: construction, screening and uses; cloning and expression vectors (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes; nucleic acid microarrays, R-DNA technology in environmental management.

UNIT 3: Ecological restoration and bioremediation

Wastewater treatment: anaerobic, aerobic process, methan ogenesis, treatment schemes for waste water: dairy, distillery, tannery, sugar, antibiotic industries; solid waste treatment: sources and management (composting, vermiculture and methane production, landfill. hazardous waste treatment). Specific bioremediation technologies: land farming, biopiles, composting, bioventing, biosparging, pump and treat method, phytoremediation; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in environment, decay behavior and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, heavy metals degradative pathways.

UNIT 4: Ecologically safe products and processes

PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated pest management; development of stress tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation and concentration of metals, metal leaching, extraction; exploitation of microbes in copper and uranium extraction, use of bioreactors for bioremediation.

Practicals: Based on the theory.

Text Books:

- Evans, G.G. & Furlong, J. 2010. *Environmental Biotechnology: Theory and Application* (2nd edition). Wiley-Blackwell Publications.
- Scagg, A.H. 2005. *Environmental Biotechnology*. Oxford University Press.

Reference Books:

- Jordening, H.J. & Winter J. 2005. *Environmental Biotechnology: Concepts and Applications*. John Wiley& Sons.
- Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995. *Molecular Cell Biology*. W.H. Freeman.
- Nelson, D.L. & Cox, M.M. 2013. *Lehninger's Principles of Biochemistry*. W.H. Freeman.
- Rittman, B.E. & McCarty, P.L. 2001. *Environmental Biotechnology. Principles and Applications.* McGraw-Hill, New York.
- Snustad, D.P. & Simmons, M.J. 2011. *Principles of Genetics* (6th edition). John Wiley& Sons.
- Wainwright, M. 1999. *An Introduction to Environmental Biotechnology*, Springer.

CORE PAPER VII

ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Introduction: The paper deals with dynamics of atmospheric processes, which include its composition, meteorological phenomena and atmospheric chemistry. The paper also highlights the anthropogenic intervention in 'anthropocene', which has led to global climate change. The paper also explores effects of global changes on human communities and initiatives taken at global and regional levels to combat them.

UNIT 1: Atmospheric circulation and energy balance

Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; *El Nino* and *La Nina*; tropical cyclone; Indian monsoon and its development, changing monsoon in Holocene in the Indian subcontinent, its impact on

agriculture and Indus valley civilization; effect of urbanization on micro climate; Asian brown clouds.
Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; green house gases (GHGs); greenhouse effect; global conveyor belt.

UNIT 2: Meteorology, atmospheric stability and chemistry

Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.

Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere.

UNIT 3: Global warming and climate change

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Milankovitch cycles, atmospheric windows.

Trends of global warming and climate change; drivers of global warming and Global Warming Potential (GWP) & climate change; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO2 fertilization and agriculture; impact on economy and spread of human diseases.

UNIT 4: Ozone layer depletion, environmental policy & agreements

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols.

Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.

Practicals: Based on the theory.

Text Books:

- Hardy, J.T. 2003. *Climate Change: Causes, Effects and Solutions*. John Wiley & Sons.
- Harvey, D. 2000. *Climate and Global Climate Change*. Prentice Hall.

Reference Books:

- Barry, R. G. 2003. *Atmosphere, Weather and Climate*. Routledge Press, UK.

- Gillespie, A. 2006. *Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations*. Martinus Nijhoff Publishers.
- Manahan, S.E. 2010. *Environmental Chemistry*. CRC Press, Taylor and Francis Group.
- Maslin, M. 2014. *Climate Change: A Very Short Introduction*. Oxford Publications.
- Mathez, E.A. 2009. *Climate Change: The Science of Global Warming and our Energy Future*. Columbia University Press.
- Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. *Climate Change and India*. Universities Press, India.
- Philander, S.G. 2012. *Encyclopedia of Global Warming and Climate Cha*nge (2nd edition). Sage Publications.

CORE PAPER VIII

SYSTEMATICS AND BIOGEOGRAPHY

Introduction: This course will discuss principles and applications of classical and modern day systematic to classification of living organisms, develop understanding of historical and contemporary patterns of distributions of organisms, and design effective conservation strategies using biogeographic theories in an era of global change and large scale human induced degradation.

UNIT 1: Concept and systematic approaches

Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy.

Definition of systematic; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, phyto-chemistry, numerical and molecular methods; taxonomy databases.

UNIT 2: Taxonomic hierarchy, Nomenclature & Systems of classification

Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification. Operational Taxonomic Units; DNA barcoding; phylogenetic tree (rooted, unrooted, ultrametric trees).

UNIT 3: Biogeography, Speciation and extinction

Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule,

Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

UNIT 4: Historical, ecological & conservation biogeography

Paleo-records of diversity and diversification; role in biogeographic patterns – past and present; biogeographical dynamics of climate change and Ice Age. Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Ishland Biogeography. Application of biogeographical rules in design of protected area and biosphere reserves.

Practicals: Based on the theory.

Text Books:

- Mani, M.S. 1974. *Ecology and Biogeography in India*. Dr. W Junk Publishers., The Hague.
- Williams, D. M., Ebach, M.C. 2008. *Foundations of Systematics and Biogeography*. Springer.

Reference Books:

- Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. *Biogeography* (4th edition). Sinauer Associates, Sunderland.
- Singh, G. 2012. *Plant Systematics: Theory and Practice* (3rd edition). Oxford & IBH Pvt. Ltd., New Delhi.
- Wheeler, Q.D. & Meier R. 2000. *Species Concepts and Phylogenetic Theory: A Debate.* Columbia University Press, New York.
- Wilkins, J. S. 2009. *Species: A History of the Idea* (Vol. 1). University of California Press.

CORE PAPER IX

URBAN ECOSYSTEMS

Introduction: The paper is designed to enable the students to examine the existing environmental issues, conflicts and their potential role in urban development. It beholds importance as interaction between urban society and its environment transpires in governance and policy decisions. It also aims to address key challenges posed by increasing development to far-reaching goal of sustainability in urban areas.

UNIT 1: Environment in an urban setting

Introduction to urbanization; urban sprawl and associated environmental issues. Man as the driver of urban ecosystem; commoditization of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).

UNIT 2: Urban dwelling

Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure, urban settings as loci of sustainability; challenges associated with sustainability and urban future.

UNIT 3: Natural spaces in a city

Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.

UNIT 4: Planning and environmental management

Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities, management of urban environment; alternative resources; policy and management decisions.

Practicals: Based on the theory.

Text Books:

- Gaston, K.J. 2010. *Urban Ecology*. Cambridge University Press, New York.
- Richter, M. & Weiland, U. (ed.). 2012. *Applied Urban Ecology*. Wiley-Blackwell, UK.

Reference Books:

- D'Monte, Darryl. 1985. *Industry versus Environment Temples or Tombs*. Three Controversies, Delhi, CSE.
- Ernstson, H. 2011. *Re-translating nature in post-apartheid Cape Town: The material semiotics of people and plants at Bottom Road*. In: Heeks, R., (Ed.) Conference on "Understanding Development through Actor-Network Theory", London School of Economics, 30 June, London.
- Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. *Science* **319**: 756-760.
- Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality. *Science as Culture* **15**: 123–138.

- McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban' between the social and natural sciences. *Urban Ecosystems* **4**: 5-24.
- Montgomery, M.R. 2009. Urban Transformation of the developing world. *Science* **319:** 761-764.

CORE PAPER X

ENVIRONMENTAL LEGISLATION AND POLICY

Introduction: This paper introduces students to the legal structure of India and fundamentals of environmental legislation and policy making. Each unit will help the students to develop basic concepts of environmental legislation and policy making in India and around the world.

UNIT 1: Legislation system in India

Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies; National Green Tribunal. Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

UNIT 2: Environmental legislation: History and policy

Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra, Yajnavalkyasmriti and Charaksamhita; Medieval period: forests as woodland and hunting resourcesduring Mughal reign; British India: Indian Penal Code 1860,Forest Act 1865, Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953.

UNIT 3: Legislative Instruments

The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; scheme and labeling of environment friendly products, Ecomarks.

UNIT 4: International laws and policy and Case studies in India

Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Convention on Biological Diversity, Montreal Protocol 1987; Kyoto Protocol 1997; Copenhagen and Paris summits.

Role of Ministry of Environment, Forests & Climate; role of central and state pollution control boards. National Green Tribunal: Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988.

Tutorial: Tutorial and case study based.

Text Books:

- Divan, S. & Rosencranz, A. 2001. *Environmental Law and Policy in India*. Oxford University Press.
- Venkat, A. 2011. *Environmental Law and Policy*. PHI Learning Private Ltd.

Reference Books:

- Abraham, C.M. 1999. *Environmental Jurisprudence in India*. Kluwer Law International.
- Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. *Bulletin of the National Institute of Ecology* 15: 227-238.
- Divan, S. & Rosencranz, A. 2002. *Environmental Law and Policy in India: Cases, Materials and Statues* (2nd edition). Oxford University Press.
- Gupta, K.R. 2006. *Environmental Legislation in India*. Atlantic Publishers and Distributors.
- Leelakrishnan, P. 2008. *Environmental Law in India* (3rd edition). LexisNexis India.
  Naseem, M. 2011. *Environmental Law in India Mohammad*. Kluwer Law International

CORE PAPER XI

BIODIVERSITY AND CONSERVATION

Introduction: This course is aimed at helping students to understand and appreciate various concepts and issues concerning biodiversity and conservation at local, regional and global levels. The course will attempt at encouraging students to appreciate the paradigm "think globally, act locally" for a sustainable common future of humankind.

UNIT 1: Levels of organization, Biodiversity patterns & estimation

Organic evolution through geographic time scale; species concept – what's in a name?, how many species are there on earth? Spatial patterns: latitudinal and altitudinal trends in biodiversity; temporal patterns fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation. Sampling strategies and surveys: phyto-sociological analysis, biomass estimation; community diversity estimation: alpha, beta and gamma diversity.

UNIT 2: Importance of biodiversity

Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and

formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

UNIT 3: Threats to biodiversity

Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis.

UNIT 4: Conservation of biodiversity

In situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources. India as a mega diversity nation; National Biodiversity Action Plan.

Practicals: Based on the theory.

Text Books:

- Gaston, K J. & Spicer, J.I. 1998. *Biodiversity: An Introduction.* Blackwell Science, London, UK.
- Primack, R.B. 2002. *Essentials of Conservation Biology* (3rd edition). Sinauer Associates, Sunderland, USA.

Reference Books:

- Krishnamurthy, K.V. 2004. *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
- Pandit, M.K. & Grumbine R.E. 2012. Ongoing and proposed hydropower development in the Himalaya and its impact on terrestrial biodiversity. *Conservation Biology* **26**:1061-1071.
- Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. *The Botanical Review* 53:80-192.
- Singh, J. S., Singh, S.P. & Gupta, S. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.
- Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. *Conservation Biology for All*. Oxford University Press.
- Sodhi, N.S., Gibson, L. & Raven, P.H. 2013. *Conservation Biology: Voices from the Tropics.*Wiley-Blackwell, Oxford, UK.

CORE PAPER XII

ORGANISMAL AND EVOLUTIONARY BIOLOGY

Introduction: This paper introduces students to the fundamentals of ecology and evolutionary biology. Each unit covers vast range of topics, which will help the students to develop basic concepts of ecology and evolutionary biology**.**

UNIT 1: History of life on Earth

Paleontology and evolutionary History; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of plants and animals; stages in primate evolution including Homo.

UNIT 2: Evolution of unicellular life

Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; Bio-geographic evidence of evolution; evolution of geographic patterns of diversity.

UNIT 3: Molecular evolution

Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

UNIT 4: Fundamentals of population genetics

Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent evolution; sexual selection; coevolution; Hardy-Weinberg Law.

Practicals: Based on the theory.

Text Books:

- Minkoff, E.C. 1983. *Evolutionary Biology*. Addison Wesley. Publishing Company.
- Nei, M. & Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.

Reference Books:

- Futuyma, D.J. 2009. *Evolution* (2nd edition). Sinauer Associates.
- Gillespie, J. H. 1991. *The Causes of Molecular Evolution*. Oxford University Press.
- Graur, D. & Li, W.H. 1999. *Fundamentals of Molecular Evolution* (2nd edition). Sinauer Associates.
- Kimura, M. 1984. *The Neutral Theory of Molecular Evolution*. Cambridge University Press.
- Nei, M. 1975. *Molecular Population Genetics and Evolution*. North-Holland Publishing Company.
- Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia University Press.
- Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. *Molecular Biology and Evolution* 15: 1647-1657.

CORE PAPER XIII

ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

Introduction: This paper deals with different aspects of environmental contamination, which have adverse effects on human health. It will lay emphasis on understanding mechanisms of pollutants impacting human health by developing an understanding of different types of pollutants, their sources and mitigation measures. The students will also be introduced to the concept of permissible limits.

UNIT 1: Chemistry of environmental pollutants

Definition of pollution; pollutants; classification of pollutants; solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage, causes of soil pollution and degradation; effect of soil pollution on environment, control strategies.

UNIT 2: Air pollution

Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NOx, SOx, PM, CO, CO_2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health. Noise pollution: sources and permissible ambient noise levels; effect on communication, impacts on life forms and humans, control measures, Radioactive material and sources of radioactive pollution.

UNIT 3: Freshwater and marine pollution

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).
Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones), thermal pollution and its effects.

UNIT 4: Pollution control

Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi.

Practicals: Based on the theory.

Text Books:

- Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2006. *Environmental and Pollution Science*. Elsevier Academic Press.
- Purohit, S.S. & Ranjan, R. 2007. *Ecology, Environment & Pollution*. Agrobios Publications.

Reference Books:

- Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. *Air Pollution: Health and Environmental Impacts*. CRC Press, Taylor & Francis.
- Hester, R.E. & Harrison, R.M. 1998. *Air Pollution and Health*. The Royal Society of Chemistry, UK.
- Park, K. 2015. *Park's Textbook of Preventive and Social Medicine* (23rd edition). Banarsidas Bhanot Publishers.
- Vesilind, P.J., Peirce, J.J., & Weiner R.F. 1990. *Environmental Pollution and Control*.Butterworth-Heinemann, USA.

CORE PAPER XIV

NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY

Introduction: This paper takes an objective view of the nature of Earth's resources, their generation, extraction and impact of human activities on earth's environment. The students are expected to understand effective management strategies. It aims to provide an idea of effective management strategies and a critical insight of the major sustainability issues.

UNIT 1: Natural resources and conservation

Resource and resource degradation; resource conservation; resource availability and factors influencing its availability; marine resources; energy resources; mineral resources; ecological, social and economic dimension of resource management, forest management strategies, strategies of water conservation; rain water harvesting; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, green revolution.

UNIT 2: Mineral resources

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

UNIT 3: Non-renewable and renewable energy resources

Oil: formation, exploration, oil shale, natural gas: exploration, liquefied petroleum gas, compressed natural gas; coal: reserves, coal gasification; environmental impacts of non renewable energy consumption; future energy options and challenges. Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; benefits of hydropower development; nuclear fission reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

UNIT 4: Resource management

Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

Tutorials: Based on the theory.

Text Books:

- Owen, O.S, Chiras, D.D, & Reganold, J.P. 1998. *Natural Resource Conservation – Management for Sustainable Future* (7th edition). Prentice Hall.

Reference Books:

- Craig, J.R., Vaughan. D.J. & Skinner. B.J. 1996. *Resources of the Earth: Origin, Use, and Environmental Impacts* (2nd edition). Prentice Hall, New Jersey.
- Freeman, A.M. 2001. *Measures of value and Resources: Resources for the Future*. Washington DC.
- Freeman, A.M. 2003. *Millennium Ecosystem Assessment: Conceptual Framework*. Island Press.
- Ginley, D.S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*. Cambridge University Press.
- Klee, G.A. 1991. *Conservation of Natural Resources*. Prentice Hall Publication.
- Miller, T.G. 2012. *Environmental Science*. Wadsworth Publishing Co.
- Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.
- Tiwari, G.N. & Ghosal. M. K. 2005. *Renewable Energy Resources: Basic Principles and Application*. Narosa Publishing House.

Discipline Specific Elective Paper I

ENERGY AND ENVIRONMENT

Introduction: This course aims to provide students with a broad understanding of the existing energy resources, issues related to energy and the environment, challenges and possible paths to sustainable energy generation and use.

UNIT 1: Energy, Demand and Energy resources

Defining energy; forms and importance; fossil fuels, advent of nuclear energy, global energy resources; renewable and non-renewable resources: distribution and availability; future technologies for capturing and integrating these resources into our energy infrastructure; energy-use scenarios in rural and urban setups; energy conservation. Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; energy subsidies and environmental costs.

UNIT 2: Energy, environment and society

Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and, urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.

UNIT 3: Energy, ecology and the environment

Energy production as driver of environmental change; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

UNIT 4: Politics of energy policy and our energy future

Political choices in energy policy globally and in the Indian context; domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbors. Current and future energy use patterns in the world and in India; alternative sources as green energy (bio fuels, wind energy, solar energy, geothermal energy; ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability.

Tutorials: Tutorial-based.

Text Books:

- Elliott, D. 1997. *Sustainable Technology. Energy, Society and Environment* (Chapter 3). New York, Routledge Press.

Reference Books:

- McKibben, B. 2012. *Global Warming's Terrifying New Math*, Rolling Stone
- Magazine.Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. *Resources of the Earth: Origin, use, and environmental impact* (2nd edition). Prentice Hall, New Jersey.
- Rowlands, I.H. 2009. *Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies* in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.
- Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.
- Mallon, K. 2006. *Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making*. EarthScan.

Discipline Specific Elective Paper II

ENVIRONMENTAL ECONOMICS

Introduction: This paper introduces students to the fundamentals of environmental economics. It covers some basic concepts of economics to familiarize students with absence of market, demand and supply in nature. Each unit covers a range of topics, which will help students develop modern concepts of environmental economics and its importance in conservation of biodiversity and ecosystems through understanding of economic costs associated with these.

UNIT 1: Environmental economics

Main characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Pareto principle or criterion; Hardin's Thesis of 'The Tragedy of Commons'; prisoner's dilemma game; methods of abatement of externalities; social cost benefit analysis; cost-effectiveness analysis.

UNIT 2: Economic solutions to environmental problems

Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement; pollution control: policies for controlling air and water pollution, disposal of toxic and hazardous waste- standards vs. emissions charges, environmental subsidies, modelling and emission charges; polluter pay principles; pollution permit trading system.

UNIT 3: Natural resource economics

Economics of non-renewable resources; economics of fuels and minerals; Hotelling's rule and extensions; taxation; economics of renewable resources; economics of water use, management of fisheries and forests; introduction to natural resource accounting.

UNIT 4: Tools for environmental economic policy

Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and valuation: discounting, principles of Cost-Benefit Analysis, estimation of costs and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.

Practicals/Tutorial: Tutorials, analysis and exercise based.

Text Books:

- Hanley, N., Shogren, J. F., & White, B. 2007. *Environmental Economics: In Theory and Practice*. Palgrave Macmillan.
- Kolstad, C.D. 2010. *Environmental Economic*s. Oxford University Press.

Reference Books:

- Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Maler, K.G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. *Ecological Economics* **15**: 91-95.
- Perman, R. 2003. *Natural Resource and Environmental Economics*. Pearson Education.
- Singh, K. & Shishodia, A. 2007. *Environmental Economics: Theory and Applications*. Sage Publications.
- Thomas, J.M. & Callan, S.J. 2007.*Environmental Economics*. Thomson Learning Inc.
- Tietenberg, T. 2004. *Environmental and Natural Resource Economics* (6th Edition). Pearson Education Pvt. Ltd.
- Tietenberg, T. H. & Lewis, L. 2010. *Environmental Economics and Policy*. Addison-Wesley.
- Turner, R. K., Pearce, D., & Bateman, I. 1994. *Environmental Economics: An Elementary Introduction*. Harvester Wheatsheaf.

Discipline Specific Elective Paper III

NATURAL HAZARDS AND DISASTER MANAGEMENT

Introduction: This paper introduces the students to various aspects of environmental hazards, their causes, classifications, and impacts. It also focuses on the management strategies and governmental action plan to mitigate and prepare for such hazards.

UNIT 1: Natural hazards

Hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, geographic distribution; floods: types and nature, frequency of flooding; landslides: causes and types of landslides, landslide analysis; drought: types of drought - meteorological, agricultural, hydrological, and famine; Glacial Lake Outburst Floods (GLOF); tornadoes, cyclone & hurricanes; tsunamis: causes and location of tsunamis; coastal erosion, sea level changes and its impact on coastal areas and coastal zone management.

UNIT 2: Anthropogenic hazards

Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from river bank, deforestation, mangroves destruction; role of construction along river banks in elevating flood hazard; disturbing flood plains. deforestation and landslide hazards associated with it; large scale developmental projects, like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.

UNIT 3: Risk and vulnerability assessment

Concept of risk and vulnerability; two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); application of geoinformatics in hazard, risk & vulnerability assessment. Concept of mitigation; types of mitigation: use of technologies in mitigations such as barrier, deflection and retention systems; importance of planning, exercise, and training in preparedness; role of public and media in hazard preparedness.

UNIT 4: Disaster management in India

Lessons from the past considering the examples of Bhuj earthquake, tsunami disaster, and Bhopal tragedy; National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management; case study of efficient disaster management during cyclone '*Phailin*' in 2013.

Practicals: Based on the theory.

Text Books:

- Schneid, T.D. & Collins, L. 2001. *Disaster Management and Preparedness*. Lewis Publishers, New York, NY.

Reference Books:

- Coppola D. P. 2007. *Introduction to International Disaster Management*. Butterworth Heinemann.
- Cutter, S.L. 2012. *Hazards Vulnerability and Environmental Justice*. EarthScan, Routledge Press.
- Keller, E. A. 1996. *Introduction to Environmental Geology*. Prentice Hall, Upper Saddle River, New Jersey.
- Pine, J.C. 2009. *Natural Hazards Analysis: Reducing the Impact of Disasters*. CRC Press, Taylor and Francis Group.
- Smith, K. 2001. *Environmental Hazards: Assessing Risk and Reducing Disaster*. Routledge Press.
- Wallace, J.M. & Hobbs, P.V. 1977. *Atmospheric Science: An Introductory Survey*. Academic Press, New York.

- Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P.&Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. *Quaternary Science Reviews* **77**: 156–166.

Discipline Specific Elective Paper IV

SOLID WASTE MANAGEMENT

Introduction: Every human activity ends up in the generation of unwanted waste product. This paper throws light on the current scenario of solid waste generation and problem in its handling and management. It also deals with the different governmental policies that explain proper transportation, handling and disposal of solid waste to minimize its effect on environment.

UNIT 1: Solid & industrial waste management

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste; impact of solid waste on environment, human and plant health; different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill; thermal treatment (pyrolysis and incineration) of waste material; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

UNIT 2: Resource Recovery

4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Concept of waste-to-energy (WTE), energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification

UNIT 3: Integrated waste management

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management. Cradle-to-grave approach; lifecycle inventory of solid waste; role of life cycle assessment (LCA) in waste management; advantage and limitation of LCA; case study on LCA of a product.

UNIT 4: Policies for solid waste management

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Eco-friendly or green products.

Practicals: Based on the theory and field-based.

Text Books:

- Bagchi, A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.

Reference Books :

- Asnani, P. U. 2006. Solid waste management. *India Infrastructure Report 570*.
- Blackman, W.C. 2001. *Basic Hazardous Waste Management*. CRC Press.
- McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.
- US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.
- White, P.R., Franke, M. &Hindle P. 1995. *Integrated Solid waste Management: A Lifecycle Inventory*. Blackie Academic & Professionals.
- Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. *Improving Municipal Solid waste Management in India.* The World Bank, Washington D.C.

Discipline Specific Elective Paper IV

Dissertation/ Research Project (College can give this choice only for students with above 60% aggregate marks)

DISSERTATION ON SOLID WASTE MANAGEMENT

Regulation for the dissertation/ project in DSE IV (Hons) Paper

The Project Paper (DSE-IV) Full Mark-100 is composed of

a) Identification of Problem	-	05 marks
b) Review of Literature	-	10 marks
c) Methodology	-	15 marks
d) Analysis	-	15 marks
e) Findings	-	15 marks
f) Presentation	-	10 marks
g) Viva-Voce	-	30 marks

Pass Mark -- 40 out of 100

The Project Paper will not have Mid Semester Examination. The project paper will be evaluated both by External and Internal Examiners. Submission of Project will carry 60 marks and Presentation and Viva-voce will carry 40 marks. Preferably students are advised to present the paper Power Point presentation method. Viva will be conducted through on the topic in the presence of external and internal examiners.

The student may choose any on one Unit/Topic given in the syllabus in DSE-IV as his/her Project. Where topic is not given in the syllabus, the concerned teachers will choose any one of the Unit/Topic of study may select as project for the students.

Remuneration to the Examiner (External/ internal) is Rs.20/- each per project Fee of Rs.50/- shall be collected from each Hons. Student at the time of Readmission to +3 III rd Year at the college level and the collected amount will be deposited in the examination account of respective colleges. The Remuneration for External & Internal may please be met from that amount.

Evaluation of project by both the examiners shall be completed before the commencement of 6th Semester Examination and the marks be uploaded through UUEMS.

Generic Elective Paper I

ENVIRONMENT AND SOCIETY

Introduction: The course examines the relationship between the environment and society enabling the students to understand and appreciate the role played by environment, society, and, their interface in shaping environmental decisions. The students will be enabled to think critically on environmental issues. Tutorials are basically MCQ type or Quiz.

UNIT 1: Development-environment conflict

Social and cultural construction of 'environment'; environmental thought from historical and contemporary perspective in light of the concepts of Gross Net Happiness and Aldo Leopold's Land Ethic. Developmental issues and related impacts such as ecological degradation; environmental pollution; development-induced displacement, resettlement, and rehabilitation: problems, concerns, and compensative mechanisms; discussion on Project Affected People (PAPs).

UNIT 2: Urbanization and environment

Production and consumption oriented approaches to environmental issues in Indian as well as global context; impact of industry and technology on environment; urban sprawl, traffic congestion and social-economic problems; conflict between economic and environmental interests.

UNIT 3: Environment, social inequalities and regulatory framework

Inequalities of race, class, gender, region, and nation-state in access to healthy and safe environments; history and politics surrounding environmental, ecological and social justice; environmental ethics, issues and possible solutions.

Regulatory framework: Brief account of Forest Conservation Act 1980 1988; Forest Dwellers Act 2008; Land Acquisition Act 1894, 2007, 2011, 2012; Land Acquisition Rehabilitation and Resettlement Act 2013.

UNIT 4: Community participation

State, corporate, civil society, community, and individual-level initiatives to ensure sustainable development; case studies of environmental movements (Appiko Movement, Chipko Movement, Narmada Bachao Andolan); corporate responsibility movement; appropriate technology movement; environmental groups and movements, citizen groups; role played by NGOs; environmental education and awareness.

Practical: Based on the theory/field work.

Text Books:

- Elliot, D. 2003. *Energy, Society and Environment, Technology for a Sustainable Future*.Routledge Press.

Reference Books:

- Chokkan, K.B., Pandya, H. & Raghunathan, H. (eds). 2004. *Understanding Environment*.Sagar Publication India Pvt. Ltd., New Delhi.
- Guha, R. 1989. *Ecological change and peasant resistance in the Himalaya*. Unquiet Woods,Oxford University Press, Delhi.
- Leopold, A. 1949. *The Land Ethic*. pp. 201-214. Chicago, USA.
- National Research Council (NRC). 1996. *Linking Science and Technology to Society's Environmental Goals*. National Academy Press.
- Pandit, M.K. 2013. Chipko: Failure of a Successful Conservation Movement. In: Sodhi, N.S.,Gibson, L. & Raven, P.H. *Conservation Biology: Voices from the Tropics.* pp. 126-127. Wiley-Blackwell, Oxford, UK.

Generic Elective Paper II

HUMAN-WILDLIFE CONFLICT AND MANAGEMENT

Introduction: This paper deals with the conflicts that have arisen as a result of shrinkage of wildlife habitats and the same being shared by human communities. It raises questions about the moral obligations of humans, need for conservation, and social impacts of conflicts. The paper aims at introducing the students to the scientific and social perspective of conservation.

Unit 1: Evolution of the concept of wildlife management

Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetkawall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; Bishnoi community; understanding wildlife management, conservation and policies regarding protected areas in 21st century; positive values provided by wildlife conservation (monetary, recreational, scientific and ecological benefits). What is the role of government, wildlife biologists and social scientists, concept of deep and shallow ecology.

Unit 2: Wildlife conservation laws in India

Need of environmental management; wildlife conservation: moral obligation? philosophy of wildlife management; Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, brief introduction to Wildlife Protection Act of

1972, Forest act 1927, Environmental Protection Act 1986, and Forest conservation Act 1920; introduction of Tiger task force, Status of current protected areas in India.

Unit 3: Socio-economic and legal basis of conflicts

Concepts of development and encroachment, who is the intruders: human or animal? Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: forest produce as a need vs. forest exploitation, introduction to tribal rights in India, demographic profile of tribes in India, importance of forest produce to tribal populations, Forest dwellers (Recognition of forest right) Act, 2006.
Insight into the important wildlife conflicts: Keoladeo National park conflict of Bharatpur, Human and elephant conflicts of Kerala, Fisherman and tiger conflict of Sundarbans forest, shifting cultivation in North east India.

Unit 4: Human wildlife coexistence

Symbiotic relationship between tribals and forest, forest and development, focus on the inclusive growth of tribes: community participation in forest management, case study of Chipko movement, sacred groves forests, India's Bishnoi community and their conservation practices; ecological economic welfare and development: conservation of indigenous culture and traditions, role of international organizations: Man and biosphere programmes; concept of conservation reserves and community reserves, importance of wildlife corridors in minimizing the conflicts and conservation.

Practical: Based on the theory.

Text Books:

- Woodroffe, R. 2005. *People and Wildlife: Conflict and Coexistence*. Cambridge.
- Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. *People and Wildlife, Conflict or Coexistence?* (No. 9). Cambridge University Press.

Reference Books:

- Conover, M. 2001. *Resolving Human Wildlife Conflicts*, CRC Press.
- Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation* **13:** 458-466.
- Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. *International Biodeterioration & Biodegradation* 45: 97-102.
- Paty, C. 2007. *Forest Government and Tribe*. Concept Publishing Company.
- Treves, A. & Karanth, K. U. 2003. Human--□carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology* **17**: 1491-1499.

Generic Elective Paper III

GENDER AND ENVIRONMENT

Introduction: The paper is designed to expose students to the concept of gender in society and its relevance in the environmental context. The principal objective of the course is to enable students to examine environmental issues from a gender-sensitized perspective.

UNIT 1: Gender and society

The socially constructed 'gender' concept; Gender existence in society; gender: matriarchy and patriarchy as means of social exclusion (case studies in an Indian context); gender equity issues in rural and urban settings.

UNIT 2: Gender and the environment

Relevance of the concept in an environmental context; evolution of gender hierarchies in historical and contemporary perspective; gendered division of roles in cultural, social and economic perspective; gender inequalities.

UNIT 3: Gender, resources and the environment

Knowledge about the environment among men and women; differential dependencies on environmental resources; implications of gendered responses to environmental degradation.

UNIT 4: Gender, environmental management and future

Women's participation in environmental movements and conservation; historical and contemporary case studies; role of women in environmental education, awareness and sustainable development.
Need for gender equity; Instruments for change: education, media, action groups, policy and management; equity in resource availability and consumption for a sustainable future.

Tutorial: Tutorial based course.

Text Books:

- Miller, B. 1993. *Sex and Gender Hierarchies*. Cambridge University Press

Reference Books:

- Agarwal, B. 1992. *The Gender and Environment Debate: Lessons from India*. Feminist Studies (Minnesota).
- Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and Temporal Shifts in Rural India: 1971-1991. *World Development* **25:** 1-42.

- Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. *World Development* **29:** 1623-1648.
- Jackson, C. 1993. Doing what comes naturally? Women and environment in development *World Development* **21:** 1947-63.
- Krishna, S. 2004. *Livelihood and Gender*. New Delhi, Sage.
- Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion rose and fell. *Development and Change* **38:** 67-85.
- Stein, R. (ed.). 2004. *New Perspectives on Environmental Justice: Gender, Sexuality, and Activism*. Rutgers University Press.
- Steingraber, S. 1998. *Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment.* New York: Vintage Books.
- Zwarteveen, M.Z. 1995. *Linking women to the main canal: Gender and irrigation management*. Gatekeeper Series 54, IIED.

Generic Elective Paper IV

GREEN TECHNOLOGIES

Introduction: This paper introduces students to the concept of green technology, its goals and advantages. It also highlights potential role of green technologies in realizing the goal of sustainable development and focuses on community participation to tap the economic benefits associated with switching to green technologies.

UNIT 1: Green technologies: concept

Definition and concepts: green technology, green energy, green economy, and green chemistry; sustainable consumption of resources; individual and community level participation, energy conservation; encouraged use of public transport instead of private transport. successful green technologies: wind turbines, solar panels; 3 R's of green technology: recycle, renew and reduce; paradigm shift from 'cradle to grave' approach. Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies.

UNIT 2: Green infrastructure, planning and economy

Green buildings; history of green buildings, need and relevance of green buildings over conventional buildings, outlined examples of green buildings; LEED certified building; Eco-mark certification, Green planning: role of governmental bodies, land use planning, concept of green cities, waste reduction and recycling in cities, public transportation for sustainable development, green belts. ; Introduction to UNEP's green economy initiative, inclusive economic growth of the society, REDD+ initiative, and cap and trade concept; green banking.

UNIT 3: Applications of green technologies

Increase in energy efficiency: cogeneration, motor system optimization, oxy-fuel firing, isothermal melting process, energy efficient fume hoods. Green House Gas (GHG) emissions

reduction: carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, methane emissions reduction and/or reuse. Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NO_X, Fluidized Bed Combustion, Dioxins reduction and removal methods, Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals, solvent recovery systems, Low Volatile Organic Compound (VOC) paints and sealers).

UNIT 4: **Green chemistry and future**

Introduction to green chemistry; principles and recognition of green criteria in chemistry; biodegradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags, green practices to conserve natural resources (organic agriculture, agroforestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly technologies.

Practicals/Tutorials: field based.

Text Books:

- Anastas, P.T. & Warner, J.C. 1998. *Green Chemistry: Theory & Practice*. Oxford University Press.
- Arceivala, S.L. 2014. *Green Technologies: For a Better Future*. Mc-Graw Hill Publications.

Reference Books:

- Baker, S. 2006. *Sustainable Development*. Routledge Press.
- Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. *Green technologies for a more sustainable agriculture* (No. 33721). United States Department of Agriculture, Economic Research Service.
- Thangavel, P. & Sridevi, G. 2015. *Environmental Sustainability: Role of Green Technologies*. Springer Publications.
- Woolley, T. & Kimmins, S. 2002. *Green Building Handbook* (Volume 1 and 2). Spon Press.

Course structure of UG Environmental Science Pass

Semester	Course	Course Name	Credits	Total marks
I	DSC-I	Ecology and ecosystems	04	75
	DSC-I Practical		02	25
II	DSC-II	Atmosphere and global climate change	04	75
	DSC-II Practical		02	25
III	DSC-III	Atmosphere and global climate change	04	75
	DSC-III Practical		02	25
IV	DSC-IV	Ecology and ecosystems natural resource management and sustainability	04	75
	DSC-IV Practical		02	25
V	DSE-I	Energy and environment	04	75
	DSE-I Practical		02	25
VI	DSE-II	Natural hazards and disaster management	04	75
	DSE-II Practical		02	25
			30	**600**

ENVIRONMENTAL SCIENCE Papers for PASS students

Discipline Specific Core Paper I

ECOLOGY AND ECOSYSTEMS

Discipline Specific Core – 4 papers

Discipline Specific Elective – 2 papers

Marks per paper – Mid term: 20 marks, End term: 80 marks, Total – 100 marks
Credit per paper – 6
Teaching hours per paper – 50 hours + 10 hours tutorial

Introduction: This paper will introduce to the students the basic understanding of ecosystem and its structural and functional aspects. It will explore the interconnectedness among all the biotic and abiotic components of environment and the dynamic nature of the ecological processes in maintaining equilibrium in nature.

UNIT 1: General concepts and Ecology of individuals

Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes.Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals.

UNIT 2: Ecology of populations and communities

Concept of population and meta-population; r- and K-selection; demographic transition, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth; deterministic and stochastic models of population dynamics; rudreal, competitive and stress-tolerance strategies. Inter- and intra-species interactions, predation, competition, ecological succession: primary and secondary successions, models and types of successions, climax community concepts.

UNIT 3: Ecosystem ecology

Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; ecosystem boundary; ecosystem function; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

UNIT 4: Biogeochemical cycles, nutrient cycling and biological invasions

Carbon cycle; nitrogen cycle; phosphorus cycle; Sulphur cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.Biological invasions: Concept of

exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways.

Practicals: Based on the theory.

Text Books:

- Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Sounders.

Reference Books:

- Groom. B. & Jenkins. M. 2000.*Global Biodiversity: Earth's Living Resources in the 21st Century.* World Conservation Press, Cambridge, UK.
- Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. *The Ecology of Plants*. Sinauer associates incorporated.
- Loreau, M. & Inchausti, P. 2002. *Biodiversity and Ecosystem functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.
- Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. *New Phytologist***203:** 697-703.
- Pimentel, D. (Ed.). 2011. *Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species*. CRC Press.
- Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications.
- Wilson, E. O. 1985. The Biological Diversity Crisis. *BioScience* **35**: 700-706.

Discipline Specific Core Paper II

ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Introduction: The paper deals with dynamics of atmospheric processes, which include its composition, meteorological phenomena and atmospheric chemistry. The paper also highlights the anthropogenic intervention in 'anthropocene', which has led to global climate change. The paper also explores effects of global changes on human communities and initiatives taken at global and regional levels to combat them.

UNIT 1: Earth's atmosphere and its Circulation

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, Milankovitch cycles; Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; green house gases (GHGs); greenhouse effect, GWP. Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; *El Nino* and *La Nina*; tropical cyclone; Indian monsoon, Indian Ocean Dipole (IOD), Impact of Indian monsoon on Indian economy.

UNIT 2: Meteorology, atmospheric stability and chemistry

Meteorological parameters; atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model. Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere.

UNIT 3: Global warming and climate change

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO2 fertilization and agriculture; impact on economy and spread of human diseases.

UNIT 4: Ozone layer, environmental policy & agreements

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances; effects of ozone depletion; mitigation measures and international protocols. Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.

Practicals: Based on the theory.

Text Books:

- Barry, R. G. 2003. *Atmosphere, Weather and Climate*. Routledge Press, UK.
- Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. *Climate Change and India*. Universities Press, India.

Reference Books:

- Gillespie, A. 2006. *Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations*. Martinus Nijhoff Publishers.
- Hardy, J.T. 2003. *Climate Change: Causes, Effects and Solutions*. John Wiley & Sons.
- Harvey, D. 2000. *Climate and Global Climate Change*. Prentice Hall.
- Manahan, S.E. 2010. *Environmental Chemistry*. CRC Press, Taylor and Francis Group.
- Maslin, M. 2014. *Climate Change: A Very Short Introduction*. Oxford Publications.
- Mathez, E.A. 2009. *Climate Change: The Science of Global Warming and our Energy Future*. Columbia University Press.
- Philander, S.G. 2012. *Encyclopedia of Global Warming and Climate Cha*nge (2nd edition). Sage Publications.

Discipline Specific Core Paper III

ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

Introduction: This paper deals with different aspects of environmental contamination, which have adverse effects on human health. It will lay emphasis on understanding mechanisms of pollutants impacting human health by developing an understanding of different types of pollutants, their sources and mitigation measures. The students will also be introduced to the concept of permissible limits.

UNIT 1: Chemistry of environmental pollutants

Definition of pollution; pollutants; classification of pollutants; solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage.

UNIT 2: Air pollution

Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health and control measures; indoor/outdoor air pollution: sources and effects on human health, emission Inventory and its application, urban air quality.

UNIT 3: Freshwater, marine and soil pollution

Sources of surface and ground water pollution; water quality parameters and standards; eutrophication; COD, BOD, DO; effect of water contaminants on human health; water borne diseases; Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

UNIT 4: Noise pollution, Radioactive/Thermal pollution and pollution control

Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans; control measures. Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects. Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters.

Practicals: Based on the theory.

Text Books:

- Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2006. *Environmental and Pollution Science*. Elsevier Academic Press.
- Purohit, S.S. & Ranjan, R. 2007. *Ecology, Environment & Pollution*. Agrobios Publications.

Reference Books:

- Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. *Air Pollution: Health and Environmental Impacts*. CRC Press, Taylor & Francis.
- Hester, R.E. & Harrison, R.M. 1998. *Air Pollution and Health*. The Royal Society of Chemistry, UK.
- Park, K. 2015. *Park's Textbook of Preventive and Social Medicine* (23rd edition). Banarsidas Bhanot Publishers.

Discipline Specific Core Paper IV

ECOLOGY AND ECOSYSTEMS NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY

Introduction: This paper takes an objective view of the nature of Earth's resources, their generation, extraction and impact of human activities on earth's environment. The students are expected to understand effective management strategies. It aims to provide an idea of effective management strategies and a critical insight of the major sustainability issues.

UNIT 1: Natural resources and conservation

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; ecological, social and economic dimension of resource management. Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources; freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: green revolution.

UNIT 2: Mineral resources

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

UNIT 3: Non-renewable energy resources

Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non- renewable

energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges.

UNIT 4: Renewable energy resources and resource management

Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, hydropower: technology; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel. Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: sustainability of society, resources and framework;

Practicals: Based on the theory.

Text Books:

- Owen, O.S, Chiras, D.D, & Reganold, J.P. 1998. *Natural Resource Conservation – Management for Sustainable Future* (7thedition). Prentice Hall.

Reference Books:

- Craig, J.R., Vaughan. D.J. & Skinner. B.J. 1996. *Resources of the Earth: Origin, Use, and Environmental Impacts* (2nd edition). Prentice Hall, New Jersey.
- Freeman, A.M. 2001. *Measures of value and Resources: Resources for the Future*. Washington DC.
- Freeman, A.M. 2003. *Millennium Ecosystem Assessment: Conceptual Framework*. Island Press.
- Ginley, D.S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*. Cambridge University Press.
- Klee, G.A. 1991. *Conservation of Natural Resources*. Prentice Hall Publication.
- Miller, T.G. 2012. *Environmental Science*. Wadsworth Publishing Co.
- Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.
- Tiwari, G.N. & Ghosal. M. K. 2005. *Renewable Energy Resources: Basic Principles and Application*. Narosa Publishing House.

Discipline Specific Elective (DSE) - Pass

Discipline Specific Elective Paper I

ENERGY AND ENVIRONMENT

Introduction: This course aims to provide students with a broad understanding of the existing energy resources, issues related to energy and the environment, challenges and possible paths to sustainable energy generation and use.

UNIT 1: Energy and Energy resources

Defining energy; forms and importance; discovery of fire, discovery of locomotive engine and fossil fuels, advent of nuclear energy; sources and sinks of energy; energy over-consumption in urban; Global energy resources; renewable and non-renewable resources: distribution and availability; past, present, and future technologies for capturing and integrating these resources into our energy infrastructure; energy-use scenarios in rural and urban setups; energy conservation.

UNIT 2: Energy demand, Energy, environment and society

Global energy demand: historical and current perspective; energy demand in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies and environmental costs. Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and, urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.

UNIT 3: Energy, ecology and the environment

Energy production as driver of environmental change; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

UNIT 4: Politics of energy policy and our energy future

Political choices in energy policy globally and in the Indian context; domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbors. Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as green energy (biofuels, wind energy, solar energy, geothermal energy; ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy mix and management from a future perspective.

Practicals: Tutorial-based.

Text Books:

- Elliott, D. 1997. *Sustainable Technology. Energy, Society and Environment* (Chapter 3). New York, Routledge Press.

Reference Books:

- McKibben, B. 2012. *Global Warming's Terrifying New Math*, Rolling Stone Magazine.
- Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. *Resources of the Earth: Origin, use, and environmental impact* (2nd edition). Prentice Hall, New Jersey.
- Rowlands, I.H. 2009. *Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies* in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.
- Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.
- Mallon, K. 2006. *Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making*. Earth Scan.
- Vesilind, P.J., Peirce, J.J., & Weiner R.F. 1990. *Environmental Pollution and Control*. Butterworth-Heinemann, USA.

Discipline Specific Elective Paper II

NATURAL HAZARDS AND DISASTER MANAGEMENT

Introduction: This paper introduces the students to various aspects of environmental hazards, their causes, classifications, and impacts. It also focuses on the management strategies and governmental action plan to mitigate and prepare for such hazards.

UNIT 1: Natural hazards

Define Hazard; concept of risk and vulnerability; reasons of vulnerability. Natural hazards: hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, floods: types and nature, landslides: causes and types of landslides; drought: types of drought - meteorological, agricultural, hydrological, and famine; tornadoes, cyclone & hurricanes; tsunamis.

UNIT 2: Anthropogenic hazards

Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from river bank, deforestation, mangroves destruction; role of construction along river banks in elevating flood hazard; disturbing flood plains. Deforestation and landslide hazards associated with it; large scale developmental projects, like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.

UNIT 3: Risk, Vulnerability, Mitigation and preparedness

Two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); Concept of mitigation; types of mitigation: structural and non-structural

mitigation, concept of preparedness; importance of planning, exercise, and training in preparedness; role of public, education and media in hazard preparedness.

UNIT 4: Disaster management in India

Lessons from the past : Bhuj earthquake, tsunami disaster, and Bhopal tragedy; National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management; case study of efficient disaster management during cyclone '*Phailin*' in 2013.

Practicals: Based on the theory.

Text Books:

- Schneid, T.D. & Collins, L. 2001. *Disaster Management and Preparedness*. Lewis Publishers, New York, NY.
- Smith, K. 2001. *Environmental Hazards: Assessing Risk and Reducing Disaster*. Rout ledge Press.

Reference Books:

- Coppola D. P. 2007. *Introduction to International Disaster Management*. Butterworth Heinemann.
- Cutter, S.L. 2012. *Hazards Vulnerability and Environmental Justice*. Earth Scan, Routledge Press.
- Keller, E. A. 1996. *Introduction to Environmental Geology*. Prentice Hall, Upper Saddle River, New Jersey.
- Pine, J.C. 2009. *Natural Hazards Analysis: Reducing the Impact of Disasters*. CRC Press, Taylor and Francis Group.
- Wallace, J.M. & Hobbs, P.V. 1977. *Atmospheric Science: An Introductory Survey*. Academic Press, New York.
- Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P.&Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. *Quaternary Science Reviews* **77**: 156–166.

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SKILL ENHANCEMENT COURSES (SEC)

Optional for SECC II paper

Total Marks- 100

Skill Enhancement Courses (SEC Option-I)

REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM & MODELING

Introduction: This course introduces the students to various computer-based and statistical methods used for study and management of natural resources and the environment. The students are expected to learn about remote-sensing techniques, physical principles, sampling, statistics and image-analysis methods.

UNIT 1:

Remote Sensing: definitions and principles; electromagnetic (EME) spectrum; interaction of EMR with Earth's surface; spectral signature; satellites and sensors; aerial photography and image interpretation. Applications and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies.

UNIT 2:

Geographical Information Systems: definitions and components; spatial and non-spatial data; raster and vector data; database generation; database management system; land use/ land cover mapping; overview of GIS software packages; GPS survey, data import, processing, and mapping.

UNIT 3:

Basic elements of statistical analyses: sampling; types of distribution – normal, binomial, poisson; measurements of central tendency: mean, median, mode; dispersion; skewness; kurtosis. Hypothesis testing; parametric and non-parametric tests; tests of significance: Chi-square test, T-test, F-test, DMRT, correlation and regression; curve fitting; analysis of variance; ordination

UNIT 4:

GIS based statistical modeling, hydrological/watershed model, air pollution dispersion model, urban pllaning, natural resource mapping, forest degradation studies, GIS based noise mapping. use of remote sensing in wildlife conservational modeling and planning.

Practicals: Based on the theory.

Text Books:

- Zar, J.H. 2010. *Biostatistical Analysis* (5th edition). Prentice Hall Publications
- Sabins, F. F. 1996. *Remote Sensing: Principles an Interpretation*. W. H. Freeman.

Reference Books:

- Edmondson, A. & Druce, D.1996.*Advanced Biology Statistics*. Oxford University Press.
- Demers, M.N. 2005. *Fundamentals of Geographic Information System*. Wiley & Sons.
- Richards, J. A. & Jia, X. 1999. *Remote Sensing and Digital Image Processing*. Springer.

Skill Enhancement Courses (SEC Option-II)

ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

Introduction: This course recognizes the growing need of industry to anticipate and incorporate environmental concerns and risks while developing large-scale projects. The course emphasizes on the contemporary tools and techniques to assess various environmental impacts and outlines various management options needed to mitigate these risks.

UNIT 1:

Environmental impact assessment (EIA): definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA. Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental management – principles, problems and strategies; environmental planning; environmental audit; introduction to ISO 14000; sustainable development.

UNIT 2:

Role of project proponents, project developers and consultants; Terms of Reference; impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management Plan (EMP)

UNIT 3:

EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects. Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment;

UNIT 4:

Risk assessment: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

Practical/Tutorial: Based on the theory.

Text Books:

- Marriott, B. 1997. *Environmental Impact Assessment: A Practical Guide*. McGraw-Hill, New York, USA.

Reference Books:

- Barrow, C.J. 2000. *Social Impact Assessment: An Introduction.* Oxford University Press.
- Glasson, J., Therivel, R., Chadwick, A. 1994. *Introduction to Environmental Impact Assessment*. London, Research Press, UK.
- Judith, P. 1999. *Handbook of Environmental Impact Assessment*. Blackwell Science.

Ability Enhancement Compulsory Course-I (AECC-I)

ENVIRONMENTAL SCIENCE

FULL MARKS: 100

Unit – I

The Environment: The Atmosphere, Hydrosphere, Lithosphere, Biosphere, Ecology, Ecosystem, Biogeochemical Cycle (Carbon Cycle, Nitrogen Cycle), Environment Pollution: Air Pollution, Water Pollution, Soil Pollution, Radiation Pollution.

Unit – II

Population Ecology: Individuals, Species, Pollution, Community, Control Methods of Population, Urbanization and its effects on Society, Communicable Diseases and its Transmission, Non-Communicable Diseases.

Unit- III

Environmental Movements in India: Grassroot Environmental movements in India, Role of women, Environmental Movements in Odisha, State Pollution Control Board, Central Pollution Control Board.

Unit –IV

Natural Resources: Conservation of Natural Resources, Management and Conservation of Wildlife, Soil Erosion and Conservation, Environmental Laws: Water Act, 1974, Air Act, 1981, The Wildlife (Protection) Act, 1972, Environment Protection, 1986, Natural Disasters and their Management.

List of minimum instrument required for undertaking practical classes of UG-CBCS in Environmental Science (Core and DSC Practicals)

1. pH meter
2. Conductivity meter
3. BOD incubator
4. COD incubator

5. Hot air oven

6. Digital balance

7. Spectrophotometer

8. Microscope

9. Electrophoretic Unit

10. Centrifuge

11. Hot air Oven

12. Distillation Unit

13. Magnetic stirrer

14. Rain gauge

15. Hydrometer

16. Psychrometer

17. Thermometer

18. Measuring tape of both metal and non metal

19. Nails, threads

20. TLC paper