INDIRA GANDHI NATIONAL TRIBAL UNIVERSITY, AMARKANTAK (M.P.)

Department of Environmental Science
Faculty of Science

SYLLABUS
FOR
BACHELOR OF SCIENCE (B.Sc.) IN ENVIRONMENTAL SCIENCE

(Effective from Session 2024-2025)

Details of papers under B.Sc. in Environmental Science

Year 1 Semester 1

Core paper 1: **EVST01:** Basics of Environmental Science
Minor paper 1: **EVSMT01:** Environment and Society
Skill Enhancement Course 1: **EVSS01:** Forest and rural livelihood
*Multi-disciplinary paper 1: **BIOMD01:** General Biology
**Minor paper: Vocational
**Ability Enhancement Compulsory Course
**Value-added paper

Year 1 Semester 2

Core paper 2: **EVST02:** Physics and Chemistry of Environment
Minor paper 2: **EVSMT02:** Pollution biology
Skill Enhancement Course 2: **EVSS02:** Solid waste management
*Multi-disciplinary paper 2: **BIOMD02:** Ecology & Environment
**Minor paper: Vocational
**Ability Enhancement Compulsory Course
**Value-added paper

Year 2 Semester 1

Core paper 3: **EVST03:** Ecology and Ecosystems
Core paper 4: **EVST04:** Environmental pollution
Minor paper 3: **EVSMT03:** Land management and soil conservation
Skill Enhancement Course 3: **EVSS03:** Remote Sensing & GIS
*Multi-disciplinary paper 3: **BIOMD03:** Modern Biology
**Minor paper: Vocational
**Ability Enhancement Compulsory Course

Year 2 Semester 2

Core paper 5: **EVST05:** Biodiversity and Conservation
Core paper 6: **EVST06:** Atmosphere and Global Climate Change
Core paper 7: **EVST07:** Organismal & Evolutionary Biology
Minor paper 4: **EVSMT04:** Green technology
Seminar 1: **EVSTS01:** Environmental Issues
**Minor paper: Vocational
**Ability Enhancement Compulsory Course

Year 3 Semester 1

Core paper 8: **EVST08:** Environmental Biotechnology
Core paper 9: **EVST09:** Environment Impact & Risk Assessment
Core paper 10: **EVST10:** Environmental legislation and policy
Generic Elective 1: **EVSGE1:** Bioindicators and Ecoremediation
Minor paper 5: **EVSMT05:**Climatology and metereology
Seminar 2: **EVSTS02:** Environmental Sustainability
Internship
**Minor paper: Vocationa

Year 3 Semester 2

Core paper 11: **EVST11:** Natural Resource management and sustainability
Core paper 12: **EVST12:** Energy and Environment
Core paper 13: **EVST13:** Urban Ecosystems
Core paper 14: **EVST14:** Environmental Microbiology &Microbial Ecology
Generic Elective 2: **EVSGE2:** Gender and environment
Minor paper 6: **EVSMT06:** Water conservation and management
**Minor paper: Vocational

Year 4 Semester 1

Core paper 15: **EVST15:** Environmental issues and human health
Core paper 16: **EVST16:** Instrumentation and analytical techniques
Core paper 17: **EVST17:** Environmental ethics and intellectual property rights (IPRs)
Core paper 18: **EVST18:** Environmental Statistics
Generic Elective 3: **EVSGE3:** Systematics and biogeography
Minor paper 7: **EVSMT07:** Human-Wildlife Conflict & Management
**Minor paper: Vocational

Year 4 Semester 2 (BSc Hon. with research)

Core paper 19: **EVST19:** Research methodology and data analysis
Minor paper 8: **EVSMT08:** Modern tools and technologiesin environmental management
Research project
**Minor paper: Vocational

Year 4 Semester 2 (BSc Hon.)

Core paper 19: **EVST19:** Research methodology and data analysis
Core paper 20: **EVST20:** Environmental hazards: Concept and management
Core paper 21: **EVST 21:** Environmental Economics
Core paper 22: **EVST 22:** Laboratory Guidance and Safety
Generic Elective 4: **EVSGE4:** Renewable energy
Minor paper 8: **EVSMT08:** Modern tools and technologiesin environmental management
**Minor paper: Vocational

*Course offered by faculty of science
**Course offered by university

Details of course under B.Sc. in Environmental Science

Credit distribution

(I) Core courses credit distribution

Sem I: 1 Core paper	3x1 =3 credits
Sem II: 1 Core paper	3x1 =3 credits
Sem III: 2 Core paper	3x2= 6 credits
Sem IV: 3 Core paper	3x3= 9 credits
Sem V: 3 Core paper	3x3= 9 credits
Sem VI: 4 Core paper	3x4= 12 credits
Sem VII: 4 Core paper	3x4 = 12 credits
Sem VIII: 1 Core paper (BSc hon. with research)	3x1= 3 credits
Sem VIII: 4 Core paper (BSc hon.)	3x4= 12 credits

Total credits from Core course:

BSc Hon. with research	3x19 = 57 credits
BSc Hon.	3x22 = 66 credits

(II) Practical work credit distribution

Sem I: 1 Practical	1x1 =1 credit
Sem II: 1 Practical	1x1 =1 credit
Sem III: 2 Practical	1x2= 2 credits
Sem IV: 3 Practical	1x3= 3 credits
Sem V: 3 Practical	1x3= 3 credits
Sem VI: 4 Practical	1x4= 4 credits
Sem VII: 4 Practical	1x4= 4 credits
Sem VIII: 1 Practical (BSc hon. with research)	1x1 =1 credit
Sem VIII: 4 Practical (BSc hon.)	1x4 = 4 credits

Total credits from Core course:

BSc Hon. with research	1x19 = 19 credits
BSc Hon.	1x22 = 22 credits

(III) Minor (theory) courses credit distribution

Semester 1 to 8	2x8 = 16 credits

(IV) Minor (Vocational theory) courses credit distribution

Semester 1 to 8	2x8 = 16 credits

V) Skill Enhancement Courses (SEC) credit distribution

Semester 1 to 3 3x3 = 9 credits

VI) Multi-disciplinary course credit distribution

Semester 1 to 3 3x3 = 9 credits

VII) Ability Enhancement Courses (AEC) credit distribution

Semester 1 to 4 2x4 = 8 credits

VIII) Value-aided Courses credit distribution

Semester 1: 2 papers 2x2=4 credits
Semester 2: 2 papers 2x2=4 credits
Total: 8 credits

IX) Seminar

Semester 4 & 5 2x2 = 4 credits

X) Internship

Semester 5 1x2 = 2 credits

XI) Research project (ForBSc Hon. with research)

Semester 8 1x12 = 12 credits

Total credits

Course	Core paper	Practical from core paper	Minor 1	Minor 2 (voc.)	SEC	Multi-disc. Course	AEC	Value aided	Seminar	Internship	Research project	Total credits
BSc hon. with research	57	19	16	16	9	9	8	8	4	2	12	160
BSc hon.	66	22	16	16	9	9	8	8	4	2	0	160

SEMESTER I

CORE PAPER 1: BASICS OF ENVIRONMENTAL SCIENCES

Code: EVST01

Unit 1: **Concept of Environment**:

Definition and concept of Environment, Biotic and abiotic biological factors in environment, Human's relationship with the environment, public awareness-Earth Summit, environmental challenges before humans & need to study the environmental sciences, modern environmental issues such as climate resilience and sustainability challenges, GIS mapping and data interpretation skills

Unit 2:Atmosphere

Origin and evolution of atmosphere, structure and composition of atmosphere; composition of air; atmospheric temperature; atmospheric pressure; earth's radiation balance

Unit 3: **Hydrosphere**

Hydrology and hydrogeology, global distribution of water, types of water, hydrological cycle, groundwater, types of aquifers, artificial recharge and rain water harvesting, water resource management.

Unit 4:Lithosphere

Definition, structure and scope-internal structure of earth and formation of core, mantle, crust, different kind of rocks and minerals, weathering, erosion, Soil formation, soil profile and classification.

Unit 5:Basics of Geology

Geological agents of changing environment viz. tectonics, Continental drift, Wegner Theory,common geological structures-bedding, fold, faults, cleavages, fractures, deposits

Recommended Practical

1. Study of major rocks and minerals
2. Microscopic study of common rocks
3. Study of toposheets/ aerial photograph.
4. Study of geomorphic features of a watershed.
5. Preparation of meteorological graphs, charts or windrose.
6. Model study of structural folds and faults

Suggested Readings

Environmental Science – Enger, Smith and Smith W.M.C. Brown companypublication
*Environmental Science - Taylar and Miller
*Environmental Science – Botkin and Kelter, John Wiley and Sons, New York.
*Environmental Science – S.C. Santra
*Environmental Science – Neble
*Environmental Science Enger Smith, Smith, W. M. C.Brown (Company Publishing
*Principles of Soil Science Watt K. E. F.(1973),(McGraw Hill Book Co., New Delhi
Validia.K.S, Environmental Geology, Tata Mc Grace Hills Publishing Co. Ltd. New Delhi.
*Barry and Choslay, Atmosphere, Weather and Climate, The English Language Book Society.
*A Text Book of Environmental Sciences, S. S. Purohit, Q. J. Shammi and A.K. Agarwal, Student Edition (Agrobios), Jodhpur.

MINOR PAPER 1: ENVIRONMENT AND SOCIETY

Code:

EVSMT01Unit1:Issuesinenvironmentalism

Socialandculturalconstructionof'environment';environmentalthoughtfromhistoricalandconte mporary perspective in light of the concepts of Gross Net Happiness and Aldo Leopold's LandEthic. Significant global environmental issues such as acid rain, climate change, and resource depletion;historical developments in cultural, social and economic issues related to land, forest, and watermanagementin aglobal context;interfacebetweenenvironmentandsociety.

Unit2:Development-environmentconflict

Developmental issues and related impacts such as ecological degradation; environmental pollution;development-
induceddisplacement,resettlement,andrehabilitation:problems,concerns,andcompensativemec hanisms; discussion onProject Affected People(PAPs).Production and consumption oriented approaches to environmental issues in Indian as well as globalcontext; impact of industry and technology on environment; urban sprawl, traffic congestion andsocial-economicproblems;conflict betweeneconomicand environmentalinterests.

Unit3:Environment-socialinequalities and community participation

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,issuesand possiblesolutions.
State,corporate,civilsociety,community,andindividual-
levelinitiativestoensuresustainabledevelopment;casestudiesofenvironmentalmovements(Appi koMovement,ChipkoMovement,Narmada BachaoAndolan); corporate responsibility movement; appropriate technology movement;environmental groups and movements, citizen

groups; role played by NGOs; environmental educationandawareness.

Suggested Readings

1. Chokkan, K.B., Pandya, H. & Raghunathan, H. (eds). 2004. *Understanding Environment*.Sagar Publication India Pvt. Ltd., New Delhi.
2. Elliot, D. 2003. *Energy, Society and Environment, Technology for a Sustainable Future*.Routledge Press.
3. Guha, R. 1989. *Ecological change and peasant resistance in the Himalaya*. Unquiet Woods,Oxford University Press, Delhi.
4. Leopold, A. 1949. *The Land Ethic*. pp. 201-214. Chicago, USA.
5. 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.

SKILL ENHANCEMENT COURSE 1: FOREST AND RURAL LIVELIHOOD

Code: EVSS01

Unit 1: Introduction

Role of forests in rural livelihood; Entrepreneur motivation for practicing apiculture, sericulture and lac cultivation, mushroom cultivation, economically important plants as cottage industry; NTFPs

Unit 2: Economic Botany

Medicinal and aromatic plants; Timber yielding plants; fibre yielding plants; food and fodder plants; floriculture; Mushroom cultivation

Unit 3: Economic Zoology

Cattle rearing and poultry; Lac cultivation, apiculture, sericulture, Vermiculture, Aquaculture

Unit 4: Organic Farming

Biofertilizer production; compost preparation; Biopesticides; Bioinsecticides; Biocontrol; Ecomarks; Organic certification

Unit 5: Community Participation

Community participation; case studies-Water Shed Management; Joint Forest Management; Role of Women in forests and rural livelihood; Afforestation and community benefits

Practical: Based on the theory and field-based.

SEMESTER II

CORE PAPER 2: PHYSICS AND CHEMISTRY OF ENVIRONMENT

Code: EVST02

Unit 1: Fundamentals of environmental physics

Quantum mechanics (relation between energy, wavelength and frequency, Beer–Lambert law, Basic concepts of pressure, force, work and energy; concept of heat transfer, conduction, convection.

Unit 2: Fundamentals of environmental chemistry

Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds; mole concept, molarity and normality, quantitative volumetric analysis,green chemistry and environmental forensics, advanced analytical techniques for pollution monitoring

Unit 3: Atmospheric chemistry

Composition of atmosphere; photochemical reactions in atmosphere; smog formation, aerosols; chemistry of acid rain, primary and secondary pollutants, ozone layer depletion, effect of air pollutants.

Unit 4: Water chemistry

Alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; heavy metals in water.

Unit 5: Soil chemistry

Soil composition; inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil; phenolic compounds in soil.

Practicals:

1. To calculate the air quality index (AQI) using the air pollutants data provided.
2. To calculate acidity, alkalinity and hardness of collected water samples.
3. To calculate the calculate chlorophyll content of plant leaf using spectrophotometer.
4. To find out soil organic carbon using Walkley and Black method.
5. To find out calorific value of plant samples using bomb calorimeter.
6. Real-world data analysis tools

Suggested Readings

1. Beard, J.M. 2013. *Environmental Chemistry in Society* (2nd edition). CRC Press.
2. Boeker, E. &Grondelle, R. 2011. *Environmental Physics: Sustainable Energy and Climate Change*. Wiley.
3. Connell, D.W. 2005. *Basic Concepts of Environmental Chemistry* (2nd edition). CRC Press.
4. Forinash, K. 2010. *Foundation of Environmental Physics*. Island Press.
5. Girard, J. 2013. *Principles of Environmental Chemistry* (3rd edition). Jones & Bartlett.
6. Harnung, S.E. & Johnson, M.S. 2012. *Chemistry and the Environment*. Cambridge University Press.

7. Hites, R.A. 2012. *Elements of Environmental Chemistry* (2nd edition). Wiley & Sons.
8. Manhan, S. E. 2000. *Fundamentals of Environmental Chemistry*. CRC Press.
9. Pani, B. 2007. *Textbook of Environmental Chemistry*. IK international Publishing House.

MINOR PAPER 2: POLLUTION BIOLOGY

Code: EVSMT02

Unit 1: Basic Concepts of Pollution

Understanding the broad concept of pollution, including its definition, sources, and types. Pollutants vs. resources; cycling of materials, tolerance ranges, carrying capacity, bioaccumulation. Cycling of Materials: Examination of biogeochemical cycles (carbon, nitrogen, phosphorus, etc.) and how they are altered by human activities. Impact of disrupted cycles on ecosystems, focusing on the accumulation of pollutants in different environmental compartments (air, water, soil); Bioaccumulation and Biomagnification:Mechanisms of bioaccumulation and Biomagnification.

Unit 2: Types of pollution

Overview of key air pollutants (e.g., particulates, SOx, NOx, ozone) and their sources.Air Pollution: Responses of plants and animals, monitoring (e.g. lichens) and control of air pollution by plants. Water pollution: Responses of plants and animals to changes in physicochemical characteristics; distribution of plants in relation to pollution (microphytes; Phytoplankton, periphyton and macrophytes);Control of Air Pollution by Plants-Role of green belts and urban forests in mitigating air pollution;Strategies for using vegetation in pollution control, including phytoremediation.

Unit 3: Biological Monitoring and Control of Aquatic and Terrestrial Pollution

Biological monitoring and control of pollution in water. Techniques for assessing water quality using biological indicators (e.g., macroinvertebrates, fish, and algal indices). Importance of biological monitoring in detecting long-term ecological changes and pollutant impacts. Soil pollution: Responses of plants to soil pollution; changes in soil characteristics by waste disposal; sanitary landfills; mining wastes, and human activities; and effects on plants and animals. Effects on Ecosystems: Broader ecological impacts of soil pollution, including changes in plant communities, loss of biodiversity, and altered ecosystem functions. Effects on terrestrial animals through changes in food availability and habitat quality.

Suggested Readings

1. Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. *Air Pollution: Health and Environmental Impacts*. CRC Press, Taylor & Francis.

2. Hester, R.E. & Harrison, R.M. 1998. *Air Pollution and Health*. The Royal Society of Chemistry, UK.
3. Park, K. 2015. *Park's Textbook of Preventive and Social Medicine* (23rd edition). Banarsidas Bhanot Publishers.
4. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2006. *Environmental and Pollution Science*. Elsevier Academic Press.
5. Purohit, S.S. & Ranjan, R. 2007. *Ecology, Environment & Pollution*. Agrobios Publications.
6. Vesilind, P.J., Peirce, J.J., & Weiner R.F. 1990. *Environmental Pollution and Control*. Butterworth-Heinemann, USA.

SKILL ENHANCEMENT COURSE 2: SOLID WASTE MANAGEMENT

Code: EVSS02

Unit 1: Introduction

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; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

Unit 2: Solid waste Management

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques, effluent treatment plant (ETP) and sewage treatment plant (STP), Concept of Integrated waste management (IWM)

Unit 3: Resource Recovery and Policies for solid waste management

4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; r mechanical biological treatment; green techniques for waste treatment. Waste treatment technologies for resource and energy recovery - basic principles; techniques of resource & energy recovery; vermicomposting Cradle to grave approach; role of Life cycle assessment **(**LCA) in 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; Ecofriendly or green products.

Practical: Based on the theory and field-based.

Suggested Readings

1. Asnani, P. U. 2006. Solid waste management. *India Infrastructure Report 570*.
2. Bagchi, A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.

3. Blackman, W.C. 2001. *Basic Hazardous Waste Management*. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.
5. US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.
6. White, P.R., Franke, M. &Hindle P. 1995. *Integrated Solid waste Management: A Lifecycle Inventory*. Blackie Academic & Professionals.
7. 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.

VALUE-AIDED COURSE: ENVIRONMENTAL EDUCATION AND DISASTER MANAGEMENT

Code: VAC-EEDM

Unit-I: Introduction to Environmental Education

Components of the environment; Environmental education and its significance, Humans and the Environment: The man-environment interaction and natural resource exploitation;Education about the environment: Environment and Ecological factors – climate; Ecosystem – Structure and functions – Major ecosystems – aquatic and terrestrial system - Energy and its flow in an ecosystem. Natural Resources: Renewable and Non-renewable Resources; Biodiversity: Levels of biological diversity, Values of biodiversity, Threats to biodiversity; Conservation of biodiversity

Unit 2: Environmental problems and their protection/management

Environmental pollution: types (Air, water, soil, and noise pollution), sources and impact of pollution on human health and ecosystems; Human population growth: Impacts on the environment, human health and welfare; Climate change: impacts, adaptation and mitigation; global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture; Land use and Land cover change: land degradation, deforestation, desertification, urbanization; Introduction to environmental laws and regulation:Environmental impact assessment; Pollution control andmanagement; Waste Management, Environment movements in India

Unit 3: Introduction to Disasters

Concepts, and definitions (Disaster, Hazard, Vulnerability, Resilience, Risks; Classification, Causes, Impacts (including social, economic, political, environmental, health, psychosocial, etc.) Urban disasters, Pandemics, Climate change; Approaches to Disaster Risk reduction

Unit 4: Inter-relationship between Disasters and Development

Factors affecting Vulnerabilities, differential impacts, impact of Development projects such as dams, embankments, changes in Land-use etc. Climate Change Adaptation. Disaster Risk Management in India Hazard and Vulnerability profile of India. Components of Disaster

Relief: Water, Food, Sanitation, Shelter, and Health; Waste Management Institutional arrangements (Mitigation, Response and Preparedness, DM Act and Policy.

Suggested Readings

- Fisher, Michael H. (2018) An Environmental History of India- From Earliest Times to theTwenty-First Century, Cambridge University Press.
- Headrick, Daniel R. (2020) Humans versus Nature- A Global Environmental History, OxfordUniversity Press
- Chiras, D. D and Reganold, J. P. (2010). Natural Resource Conservation: Management for a
- Sustainable Future.10th edition, Upper Saddle River, N. J. Benjamin/Cummins/Pearson.
- John W. Twidell and Anthony D. (2015). Renewable Energy Sources, 3rd Edition, Weir Publisher(ELBS)
- Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource
- Conservation. Anamaya Publications
- Harper, Charles L. (2017) Environment and Society, Human Perspectives on EnvironmentalIssues 6th Edition. Routledge.
- Harris, Frances (2012) Global Environmental Issues, 2nd Edition. Wiley- Blackwell.
- Krishnamurthy, K.V. (2003) Textbook of Biodiversity, Science Publishers, Plymouth, UK
- Jackson, A. R., & Jackson, J. M. (2000). Environmental Science: The Natural Environment andHuman Impact. Pearson Education.
- Masters, G. M., & Ela, W. P. (2008). Introduction to environmental engineering and science (No.60457). Englewood Cliffs, NJ: Prentice Hall.
- Miller, G. T., &Spoolman, S. (2015) Environmental Science. Cengage Learning.
- Barnett, J. & S. O'Neill (2010). Maladaptation. Global Environmental Change—Humanand Policy Dimensions 20: 211–213
- Jørgensen, Sven Marques, Erik João Carlos and Nielsen, Søren Nors (2016) Integrated
- Environmental Management, A transdisciplinary Approach. CRC Press.
- Theodore, M. K. and Theodore, Louis (2021) Introduction to Environmental Management, 2nd Edition. CRC Press.

SEMESTER III

CORE PAPER 3: ECOLOGY AND ECOSYSTEMS

Code: EVST03

Unit 1: Introduction

Basic concepts and definitions: ecology and ecosystem, 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: fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals,climate-driven changes in ecosystems and case studies on ecosystem management

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, life forms, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; biotic 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.

Unit 4: Ecosystem Types and Dynamics: Structure, Function, and Energy Flow

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 5: Nutrient Cycles and Ecosystem Dynamics

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,advanced ecological modeling techniques and biodiversity informatics

Practical: Based on the theory.

Suggested Readings

1. Groom. B. & Jenkins. M. 2000.*Global Biodiversity: Earth's Living Resources in the 21st Century.* World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. *The Ecology of Plants*. Sinauer associates incorporated.
3. Loreau, M. & Inchausti, P. 2002. *Biodiversity and Ecosystem functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Sounders.
5. 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.
6. Pimentel, D. (Ed.). 2011. *Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species*. CRC Press.
7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. *BioScience***35**: 700-706.

CORE COURSE 4: ENVIRONMENTAL POLLUTION

Code: EVST04

Unit 1: Air pollution

Definition of pollution; pollutants; classification of pollutants. 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 formation and its types, effects of different pollutants on human health (NOx, SOx, PM, CO, CO2, hydrocarbons and VOCs) and control measures, urban air quality and plastic pollution management

Unit 2: Water pollution

Sources of surface and ground water pollution; water quality parameters and standards; eutrophication; biomagnifications, COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; Water pollution control strategies; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management, emerging contaminants such as microplastics, e-waste, and pharmaceutical waste

Unit 3: Soil pollution

Causes of soil pollution and degradation; effect of soil pollution on environment (Vegetation and other life forms), Persistent organic pollutant (POP) and their classification, control strategies, current case studies on pollution control technologies

Unit 4: Noise pollution

Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; Monitoring of noise pollution management & control

Unit 5: Radioactive and thermal pollution

Radioactive material and sources of radioactive pollution; effect of radiation on humanhealth; thermal pollution and its effects.

Practical: Based on the theory

Suggested Readings

1. Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. Air Pollution: Health and EnvironmentalImpacts. CRC Press, Taylor & Francis.
2. Hester, R.E. & Harrison, R.M. 1998. Air Pollution and Health. The Royal Society ofChemistry, UK.
3. Park, K. 2015. Park's Textbook of Preventive and Social Medicine (23rd edition).BanarsidasBhanot Publishers.
4. Pepper, I.L., Gerba, C.P. &Brusseau, M.L. 2006. Environmental and Pollution Science.Elsevier Academic Press.
5. Purohit, S.S. & Ranjan, R. 2007. Ecology, Environment & Pollution. AgrobiosPublications.
6. Vesilind, P.J., Peirce, J.J., & Weiner R.F. 1990. Environmental Pollution and Control.Butterworth-Heinemann, USA

MINOR PAPER 3:LAND MANAGEMENT AND SOIL CONSERVATION

Code: EVSMT03

Unit 1: Introduction

Concept and techniques of land use planning, land restoration, land resources and human impact, land development and land forming for irrigation, sustainable land management. agriculture land management, traditional land management practices.

Unit 2: Soil genesis

Soil and its formation, Composition and properties of soil, soil water, soil air, soil organisms,

pests and diseases, Growth and expression, Humus and its constituents, Soil organic matter

Unit 3: Soil fertility and health

Factors affecting soil organic matter content, Physicochemical properties of soil, Soil health, Soil fertility & productivity, Soil profile, Soil reaction, Soil acidity. Soil pH and plant growth, Soil salinity, Saline and Sodic soils, Different types of soil in India.

Unit 4: Soil management

Soil Fauna and Trophic Interactions, Carbon Cycle, Nitrogen Mineralization and Immobilization, Nitrogen Inputs Soil Crusts and Soil Formation, Nitrification and Denitrification, Soil Degradation, C/N ratio, micro flora, microfauna- their relation for soil management.

Unit 5: Soil conservation

Soil conservation planning. Soil conservation methods and strategies in India, Nitrogen, phosphorus and potassium economy in soil.

Recommended Books

- Environmental Geography, Savindra Singh, Prayag Pustak Bhavan, Allahabad.
- Environment Land use planning and Management, Anmol Publishers, New Delhi (1993)
- Trivedi R.K., Environment and Natural Resources Conservation, 1994
- Environmental Science, Anil Tyagi, Danika publishing company, New Delhi, 2007.
- R. K. Trivedi 'Physicochemical analysis of soil'
- Willard 'Instrumental Methods of Analysis'
- Essential Environmental Studies, 2009. S.P. Misra, S.N. Pandey, (Ane Books Pvt. Ltd, Chennai)
- Text Book of Environmental Studies, Erach Bharucha, 2005.Orient Longman Pvt. Ltd., Ernakulam

SKILL ENHANCEMENT COURSE 3: REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

Code: EVSS03

Unit 1: Introduction of the Topographical features

Maps: Types, scale, minimum mapping unit, topographical features on a map, drainage, stream orders, slope estimation from contours, maps in environmental planning and management for land use/ cover, forests, landforms, settlements, and communication network

Unit 2: Aerial remote sensing and satellite systems

Remote sensing: Principle and concept of remote sensing, definition, electromagnetic Spectrum, remote sensing platforms, optical, thermal and microwave sensors, ground truth data collection. Interaction between light and matter, spectral signatures of plants, water, and

rocks in different spectral regions. Date acquisition: aerial photography, cameras, satellite data: Orbits (sun synchronous, geosynchronous, Polar), Multispectral scanners, CCD cameras, land sat, SPOT & IRS Imager analysis: elements of aerial photographic interpretation, stereoscopic data analysis, series of satellites

Unit 3: Digital image processing and Application of RS & GIS techniques

Digital Data Analysis: Image characteristics, pre-processing, image classification (supervised and unsupervised), change detections, commercially available software's. Geographical Information system: Terminology, raster and vector GIS, database creation, data storage, database standards. Applications of RS and GIS in forestry, Agriculture, wetlands, water resources, natural hazards (landslides, forest fire)

Practical: Based on the theory

Suggested Readings

1. A. Ganesh. (2006). Application of Geospatial Technology. Satish Serial Pub. House, Delhi.
2. Burrough PA. 1990. *Principles of GIS for Land Resources Assessment*. Oxford & IBH.
3. Chouhan, T.S. and Joshi, K.N. (1992). Remote Sensing for Natural Resources Management. Universal Scientific Publication, Jaipur.
4. Colwell, Robert W. (1971). Monitoring of Earth Resources from Aircraft and Spacecraft, NASA. Washington D.C.
5. Davidson, Donald A. (1998). Soils and Land Use Planning, Longman, London.
6. George Joseph.(2005). Fundamentals of Remote Sensing. University Press (India) Ltd. Hyderabad.
7. John, R. Jensen, (2009). Remote Sensing of the Environment: An Earth Resource Perspective. Dorling Kindersley (India) Pvt. Ltd., NOIDA, India.
8. Lillsand TM. 1989. *Remote Sensing and Image Interpretation*. John Wiley.
9. Murk and Skinner. (1999). Geology Today- Understanding Our Planet, John Wiley and Sons Inc, New York.
10. Narayanan LRA. 1999. *Remote Sensing and its Application*. Universities Press (India) /Orient Longman.
11. P.A. Burrough. (2007). Principles of Geographic Information System. Oxford University Press, USA.
12. Remote sensing and image interpretation (Fifth edition, 2007) by Thomas M. Lilesand, Ralph W. Kiefer, Jonathan W. Chapman Wiley India publication, New Delhi.
13. Remote sensing of the environment (2000) John R. Jensen, Dorling Kindersley India Pvt. Ltd.
14. Sharma NK. 1986. *Remote Sensing and Forest Survey*. International Book Distr.

SEMESTER IV

CORE PAPER 5: BIODIVERSITY AND CONSERVATION

Code: EVST05

Unit 1:Introduction

Basic concepts; Types (Species diversity, Genetic diversity, Ecosystem diversity); Measurement of biodiversity, genetic diversity estimation: Molecular marker; advanced molecular techniques for biodiversity assessment (e.g., eDNA), Mega-diversity countries; concept of biodiversity hot spots

Unit 2: Importance of biodiversity

Economic importance of biodiversity – medicinal plants, drugs, fisheries and livelihoods; ecological services, ecosystem services and ethical values of biodiversity

Unit 3:Threats to biodiversity

Threat to biodiversity: Natural and anthropogenic disturbances; habitat loss, habitat degradation and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; invasive species; man and wildlife conflicts; consequences of biodiversity loss

Unit 4:Conservation of biodiversity

IUCN Red List categorization – guidelines, practice and application; Red Data book; In-situ conservation: National Parks, Wildlife Sanctuaries, Biosphere Reserves; Ex-situ conservation: botanical gardens, zoological gardens, gene banks, seed banks, pollen culture, Cryopreservation, DNA banks, role of local communities and traditional knowledge in conservation,community conservation and biodiversity restoration projects

Unit 5: Biodiversity in India

India as a mega diversity nation; status of protected areas and biosphere reserves in the country; threatened plants and animals of India, National Biodiversity Action Plan, Important conservation projects; National conventions, treaties and protocols for Biodiversity Conservation

Practical: Based on the theory.

Suggested Readings

1. Gaston, K J. & Spicer, J.I. 1998. *Biodiversity: An Introduction.* Blackwell Science, London, UK.
2. Krishnamurthy, K.V. 2004. *An Advanced Text Book of Biodiversity - Principles and Practices.* Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
3. 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.
4. Primack, R.B. 2002. *Essentials of Conservation Biology* (3rd edition). Sinauer Associates, Sunderland, USA.
5. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. *The Botanical Review* **53**: 80-192.
6. Singh, J. S., Singh, S.P. & Gupta, S. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.
7. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. *Conservation Biology for All*. Oxford University Press.
8. Sodhi, N.S., Gibson, L. & Raven, P.H. 2013. *Conservation Biology: Voices from the Tropics.* Wiley-Blackwell, Oxford, UK.38

CORE COURSE 6: ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Code: EVST06

Unit 1: Introduction

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Earth's energy balance; energy transfers in atmosphere; greenhouse gases)GHGs(; greenhouse effect; global conveyor belt

Unit 2: Meteorology, atmospheric stability and atmospheric circulation

Basics of Meteorology, Meteorological parameters)temperature, relative humidity, wind speed and direction, precipitation(; atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model. Movement of air masses; air and sea interaction; southern oscillation; western disturbances; *El Nino* and *La Nina*; tropical cyclone; Indian monsoon and its development

Unit 3: Atmospheric chemistry

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 4: Global warming and climate change

Earth's climate through ages; General aspects of global climate change, drivers of global warming and the potential of different greenhouse gases)GHGs(causing the climate change; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural

productivity and biological responses - range shift of species

Unit 5: Ozone layer depletion

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; ozone depleting substances)ODS(; effects of ozone depletion; mitigation measures and international protocols.climate change policy, mitigation strategies, International agreements; Convention on Climate Change; Carbon foot print and carbon credit

Practical: Based on the theory.

Suggested Readings:

1. Barry, R. G. 2003. *Atmosphere, Weather and Climate*. Routledge Press, UK.
2. Gillespie, A. 2006. *Climate Change, Ozone Depletion and Air Pollution: Legal Commentarieswith Policy and Science Considerations.* Martinus Nijhoff Publishers.
3. Hardy, J.T. 2003. *Climate Change: Causes, Effects and Solutions*. John Wiley & Sons.
4. Harvey, D. 2000. *Climate and Global Climate Change*. Prentice Hall.
5. Manahan, S.E. 2010. *Environmental Chemistry*. CRC Press, Taylor and Francis Group.
6. Maslin, M. 2014. *Climate Change: A Very Short Introduction*. Oxford Publications.
7. Mathez, E.A. 2009. *Climate Change: The Science of Global Warming and our Energy Future*. Columbia University Press.
8. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. *ClimateChange and India.* Universities Press, India.
9. Philander, S.G. 2012. *Encyclopedia of Global Warming and Climate Cha*nge)2nd edition(. Sage Publications.

CORE COURSE 7: ORGANISMAL AND EVOLUTIONARY BIOLOGY

Code: EVST07

Unit 1: History and evolution of life on Earth

Palaeontology and evolutionary History; evolutionary time scale, major events in the evolutionary time scale; origins of unicellular and multi-cellular organisms; major groups ofplants and animals; stages in primate evolution including Homo. Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitnessand natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis

Unit 2: Evolution of unicellular life

Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organicmonomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; evolution ofprokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes;

anaerobic metabolism,photosynthesis and aerobic metabolism

Unit 3: Geography of evolution

Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographicdistribution; evolution of geographic patterns of diversity

Unit 4: Molecular evolution

Neutral evolution; molecular divergence and molecular clocks; genomic tools for studying evolution, such as phylogenomics: molecular tools in phylogeny,classification and identification; protein and nucleotide sequence analysis; origin of new genes andproteins; gene duplication and divergence,

Unit 5: Fundamentals of population genetics

Concepts of populations, conservation genetics and adaptive evolution, gene pool, gene frequency; concepts and rate of change in gene frequencythrough natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms;convergent evolution; sexual selection; coevolution;Hardy-Weinberg Law.

Practical: Based on the theory.

Suggested Readings

1. Futuyma, D.J. 2009. *Evolution* (2nd edition). Sinauer Associates.
2. Gillespie, J. H. 1991. *The Causes of Molecular Evolution*. Oxford University Press.
3. Graur, D. & Li, W.H. 1999. *Fundamentals of Molecular Evolution* (2nd edition). Sinauer Associates.
4. Kimura, M. 1984. *The Neutral Theory of Molecular Evolution*. Cambridge University Press.
5. Minkoff, E.C. 1983. *Evolutionary Biology*. Addison Wesley. Publishing Company.
6. Nei, M. & Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.
7. Nei, M. 1975. *Molecular Population Genetics and Evolution*. North-Holland Publishing Company.
8. Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia university press.
9. 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.

MINOR PAPER 4: GREEN TECHNOLOGY

Code: EVSMT04

Unit 1: Green technologies

Green technologies in historical and contemporary perspectives; successful green technologies: windturbines, solar panels; 3 R's of green technology: recycle, renew and reduce; paradigm shift from 'cradle to cradle' to 'cradle to grave'

Unit 2: **Green infrastructure, planning and economy**

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, green belts.; Introduction to UNEP'sgreen economy, REDD+ initiative, and cap andtrade concept; green banking

Unit 3: Applications of green technologies

Increase energy efficiency, compact fluorescent lights)CFLs(, motion detectionlighting,Greenhouse Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, fuel-efficient vehicles, public transport, methane emissions reduction, Green chemistry principles and applications, role of green technologies towards asustainable future

Suggested Readings

- 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.
- Baker, S. 2006. *Sustainable Development*. Routledge Press.
- Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. *Green technologies for a more sustainableagriculture*)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.

SEMESTER V

CORE PAPER 8: ENVIRONMENTAL BIOTECHNOLOGY

Code: EVST08

Unit 1:Recombinant DNA technology

Recombinant DNA technology: toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, reverse transcriptase, Taq polymerase), ligases, other DNA modifying enzymes, cloning vectors: plasmids, bacteriophage, phagmids, cosmids, YAC, BAC; gene cloning, genomic and cDNA libraries: construction, screening and uses

Unit 2: Basic knowledge of biotechnological techniques and their applications

Polymerase chain reaction, molecular marker, Elementary information of gene transfer in plants, Basic concept of genetic engineering of plants and its applications, Plant tissue culture and its applications

Unit 3: Biotechnology for pollution control

Bioremediation- Concepts, Need & types, Environmental Application of Bioremediation, Biodegradation of Xenobiotic compounds, Microbial remediation; Phytoremediation – Basic Concepts, Biological Cleaning up of the environment with plants. Genetically modified microbes and their uses in pollution control,Concept of superbug, Biotechnological approaches for wastewater and solid waste management, biotech-based solutions to pollution, Bioenergy

Unit 4: Ecological restoration

Biofertilizers; VAM; Vermiculture and organic farming; Biocontrol agents: Biopesticide, Bioherbicides, Bioinsecticide, Degradation of lingo-cellulosic waste; Process of Methanogenesis; Biogas production, synthetic biology and its applications in environmental restoration

Unit 5:Industrial applications of microbial technology

Fermentation, Bioreactors, Microbial production of industrial products; Industrial applications of microbes including products for health-pharmaceutical, food and beverage industry and biofuels

Practicals: Based on the theory

Suggested Readings

1. Evans, G.G. & Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2nd edition). Wiley-Blackwell Publications.
2. Jordening, H.J., Winter J. 2005. Environmental Biotechnology: Concepts and Applications.John Wiley& Sons.
3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995.Molecular Cell Biology. W.H. Freeman.

4. Nelson, D.L. & Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.

5. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles andApplications. McGraw-Hill, New York.
6. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press.
7. Snustad, D.P. & Simmons, M.J. 2011. Principles of Genetics (6th edition). John Wiley& Sons.
8. Wainwright, M. 1999. An Introduction to Environmental Biotechnology. Springer.
9. A Textbook of Biotechnology: R. C. Dubey, S. Chand & Company, New Delhi (2002).
10. Biotechnology: B.D. Singh, Kalyani Publishers

CORE PAPER 9: ENVIRONMENT IMPACT & RISK ASSESSMENT

Code: EVST09

Unit 1: Environmental impact assessment

Definitions, introduction, and concepts; scope and methodologies of EIA; 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 2: Strategies in EIA

Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefitanalysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO 14000

Unit 3: Indian scenario

EIA regulations in India; status of EIA in India; current issues in EIA; case study ofhydropower projects/ thermal projects, real-world case studies of infrastructure projects and their environmental assessments

Unit 4: Risk assessment

Introduction and scope; project planning; exposure assessment; toxicityassessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment,automated impact assessment tools and environmental risk software

Practicals: Based on the theory.

Suggested Readings

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

CORE PAPER 10: ENVIRONMENT IMPACT & RISK ASSESSMENT

Code: EVST10

Unit 1: Environmental Governance and Law 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. Environmental concern in Indian society, need for environmental legislation in Indian context. The National Green Tribunal Act 2010

Unit 2: Environmental legislation and institution framework

International environmental agreements and climate treaties: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(. 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; 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; scheme and labelling of environment-friendly products, Ecomarks.

Unit 3: International laws and policy

Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro)Rio Declaration, Agenda 21(; Montreal Protocol 1987; Kyoto Protocol 1997; Copenhagen and Paris summits; Ramsar convention, recent international environmental treaties and summits, climate diplomacy

Unit 4: Government institutions

Role of Ministry of Environment, Forests & Climate Changein environmental law and policy-making; the role of central and state pollution control boards in environmental law and policy making.

Practical: Tutorial and case study based: mock environmental policies/ simulation policy debates

Suggested Readings

1. Abraham, C.M. 1999. *Environmental Jurisprudence in India*. Kluwer Law International.

2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. *Bulletin of theNational Institute of Ecology* **15**: 227-238.

3. Divan, S. & Rosencranz, A. 2001. *Environmental Law and Policy in India*. Oxford University Press.
4. Divan, S. & Rosencranz, A. 2002. *Environmental Law and Policy in India: Cases, Materialsand Statues*)2nd edition(. Oxford University Press.
5. Gupta, K.R. 2006. *Environmental Legislation in India*. Atlantic Publishers and Distributors.
6. Leelakrishnan, P. 2008. *Environmental Law in India*)3rd edition(. LexisNexis India.
7. Naseem, M. 2011. *Environmental Law in India Mohammad*. Kluwer Law International.
8. Venkat, A. 2011. *Environmental Law and Policy*. PHI Learning Private Ltd.

MINOR PAPER 5: CLIMATOLOGY AND METEREOLOGY

Code: EVSMT05

Unit 1:

Understanding the meteorological parameters-temperature, humidity, rainfall; wind speed and direction, atmospheric pressure, atmospheric stability and mixing heights

Unit 2:

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Earth's energy balance; energy transfers in atmosphere

Unit 3

Tropical monsoon-causes, and impacts, types of wind, precipitation, General aspects of global climate change, greenhouse gases)GHGs), impact of climate change

Recommended Books

*****General climatology: Critichfield H. J.
*Climatology: Fundamentals and Applications: Mater J. R.
*Climatology: Selected Applications: Henry D. Foth
*Introduction to weather and climate: Trewartha
*The Atmosphere: An Introduction to Meterology: Fedrik K. Lutgen, E. J. Tarbuck
*General Meteorology: H. R. Byers (Tata Mc Grew – Hill Publications, New Delhi)
*Environmental Geography, Savindra Singh, Prayag Pustak Bhavan,
Allahabad.
*R. K. Trivedi 'Physicochemical analysis of water and soil'
*Willard 'Instrumental Methods of Analysis'

SEMESTER VI

CORE PAPER 11: NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY

Code: EVST11

Unit 1: Fundamentals of Water Resources

Definition and Classification of Water Resources**,** Hydrological Cycle**,** Global Water Distribution**,** Water Scarcity and Availability, Water Use in Agriculture, Industry, and Domestic Sectors**,** Water Conflicts and Management Challenges

Unit 2: Land and mineral resources

Land Resources: Definition and Types of Land Resources, Land Use and Land Cover: Concepts and Classification, Soil Erosion, Desertification, and Deforestation**,** Soil Conservation Techniques, Sustainable Agriculture and Land Management

Mineral Resources:

Definition and Classification of Minerals, Types of Mineral Resources: Metallic, Non-Metallic, and Energy Minerals, Mining and Its Environmental Consequences, Sustainable Mineral Resource Management

Unit 3: Forest Resources

Global and Indian Forest Cover, types and importance of forests, Sustainable Harvesting Techniques, National Forest Policies, Forest Conservation Act, Forest Conservation Techniques, National parks and sanctuaries, Biosphere reserves

Unit 4 Agricultural resources

Agricultural resource: World food problems, factors affecting crop production, impact of modern agricultural practices on environment, water lodging and salinity problems, Pest and Disease Management in Field Crops, Livestock resource: Livestock's resource in India: an overview, Health and Disease Management in Livestock,

Unit 5: Sustainable development

Concept and principles of sustainable development, Environmental degradation and conservation issue: Rehabilitation of degraded rural landscape, Rehabilitation of specialized habitats, e.g water bodies, mangroves, Challenges and opportunities for sustainability in

developing countries, Policy frameworks for sustainable development, ecosystem services valuation and sustainable land use planning, natural capital accounting methods and case studies on circular economy initiatives in resource management

Practical: Based on the theory

Suggested Readings

- A text book of Environmental Studies., 2006. D.K. Asthana, Meera Asthana (Chand & Co.)
- Essential Environmental Studies, 2009, S.P. Misra, S.N. Pandey, (Ane Books Pvt. Ltd. Chennai)
- Text Book of Environmental Studies, Ernch Bharucha, 2005.Orient Longman Pvt. Ltd Ernakulam
- Principles of Environmental Biology P.K. G. Nair (Himalaya Publ, House, N, Delhi
- Environmental Biology M. P. Arora (Himalaya Publishing House, New Delhi)

CORE PAPER 12: ENERGY AND ENVIRONMENT

Code: EVST12

Unit 1: Introduction

Defining energy; forms and importance; energy use from a historical perspective: discovery of fire, discovery of locomotive engine and fossil fuels, electrification of cities, oil wars in the Middle East, advent of nuclear energy; sources and sinks of energy; energy over-consumption in urban setting, renewable energy economics and life cycle analysis of different energy systems

Unit 2: Energy resources

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 3: Energy demand

Global energy demand: historical and current perspective; energy demand and use 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, energy audits, carbon reduction strategies, and energy management technologies

Unit 4: 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 5: Politics of energy policy

Political choices in energy policy globally and in the Indian context)historical and contemporary case studies(; domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbours

Practical: Tutorial-based

Suggested Readings

- 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.
- Elliott, D. 1997. *Sustainable Technology*. *Energy, Society and Environment* (Chapter 3). New York, Routledge Press.
- Rowlands, I.H. 2009. *Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies* in Debora L. Van Nijnatten and Robert Boardman (eds), CanadianEnvironmental 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.

CORE PAPER 13: URBAN ECOSYSTEMS

Code: EVST13

Unit1:Environmentin anurbansetting

Introductiontourbanization;urbansprawlandassociatedenvironmentalissues. Man as the driver of urban ecosystem; commodification of nature; metros, cities and towns as sourcesandsinksofresources;resourceconsumptionanditssocial,cultural,economicandecologic alperspectives; urban transformation; increasing challenges posed by modernity for the environment;urbanpollution (air, water, soil)

Unit2: Urbandwelling

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 wellasaccumulation;environmental costs ofurban infrastructure.

Unit3:Urbaninterfacewiththeenvironment

Management of urban environment; alternative resources; policy and management decisions; urbansettingsaslociof sustainability;challengesassociated withsustainabilityand urbanfuture

Unit4: Naturalspaces in acity

Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization
andplanningofgreenspacessuchasparks,gardensandpublicspaces;conceptofgreenbelts;urbann aturalforest ecosystem as green lungs,urban resilience, sustainable cities, and smart city initiatives, green infrastructure planning and urban biodiversity conservation

Unit5:Planningandenvironmentalmanagement

Urban planning and its environmental aspects from historical and contemporary perspectives;
benefitsofenvironmentalmanagement;introductiontogreenbuildings;urbangovernance;politic alcomplexityofapplying ecologicalscienceto urbanpolicyand planning,smartcities

Practical: Basedonthetheory

Suggested Readings

- 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 "UnderstandingDevelopment through Actor-Network Theory", London School of Economics, 30 June, London.
- Gaston, K.J. 2010. *Urban Ecology*. Cambridge University Press, New York.
- 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.
- Richter, M. & Weiland, U. (ed.). 2012. *Applied Urban Ecology*. Wiley-Blackwell, UK.

CORE PAPER 14: ENVIRONMENTAL MICROBIOLOGY & MICROBIAL ECOLOGY

Code: EVST14

Unit 1: Introduction

Environmental Microbiology: Definition and Scope; Biodiversity of microbes, General characteristics of different microbial groups; Environmental microbial processes: an introduction, Microbial Ecology: Definition

Unit 2: Microorganisms & their natural habitats

Terrestrial Environment: Soil as a natural habitat of microbes, Soil microflora
Aquatic Environment: Microflora of Freshwater & Marine habitats
Aeromicroflora: Distribution and sources of air borne microorganisms
Microbes in/on human body (Microbiomics) & animal (ruminants) body.
Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, salinity, & low nutrient levels

Unit 3: Microbial Interactions

Classification of microbial interactions: Mutualism, Synergism, Commensalism, Competition, Amensalism, Parasitism, Predation
Microbe-microbe interaction: Lichen (Algae-Fungi Interaction), Mycoparasitism (Fungus-Fungus Interaction), Mycophagy, Bacterivores, Bacteriophage
Microbe–Plant Interactions: Root-microbe interaction, relationship of aerial plant surfaces with microorganism
Microbe–Animal Interactions: Role of Microbes in Ruminants, Nematophagus fungi, Luminescent bacteria as symbiont, Microorganism-Insect Mutualisms

Unit 4: Microbial biogeochemical processes of nutrient cycling and biodegradation

Carbon cycle: Microbial degradation of polysaccharide (cellulose, hemicellulose, lignin, chitin)
Nitrogen cycle: Ammonification, nitrification, denitrification & nitrate reduction
Phosphorous cycle: Phosphate immobilization and phosphate solubilization
Sulphur Cycle: Microbes involved in sulphur cycle

Unit 5: Environmental Microbiology in Sustainable Development

Microbial services in soil fertility: Plant Growth Promotory Rhizobacteria (PGPRs), Biofertilizers, Biological Nitrogen Fixation; Microbial production processes in pharmaceutical industries: antibiotics and vaccines; Microbial production of bio-pesticides; Microbes in industrial applications: fermentation, biofuel,microbial applications in wastewater treatment and biogeochemical cycling, microbial fuel cells

Practical: Basedonthetheory

Recommended books

*Lansing M. Prescott, John P. Harley, Donald A. Klein. Microbiology, 5th Edition, The McGraw−Hill Companies, 2002
Microbiology-M.J. Pelczar, E.C.S. Chan, N.R. Kreig.1996. Mc Graw Hill Books Co.,Newyork
*Microbiology-Fundamentals and Applications. Atlas, R.M. Macmillian Pub. Co., New York
*A text book of Microbiology. Ananthanarayanan, R and Jayaram Panicker

MINOR PAPER 6: WATER CONSERVATION AND MANAGEMENT

Code: EVSMT06

Unit 1: Introduction

Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapo-transpiration; classification of water resources (oceans, rivers, lakes and wetlands), Physical, chemical and biological properties of water

Unit 2: Surface and subsurface water

Introduction to surface and ground water; surface and ground water pollution; formation and properties of aquifers; techniques for ground water recharge; importance of watershed and watershed management; rain water harvesting technique, wetland conservation and management; Ramsar Convention, 1971; major wetlands of India

Unit 3 :Water resource and its problems in India

Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; Water resources and sharing problems, Social and ecological issues related to Dam, international conflicts on water sharing between India and her neighbours, National water policy; water pollution (control and prevention) Act 1972; Ganges water treaty.

Suggested Readings

- 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.
- Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-Hill Publications.
- Schward& Zhang, 2003. *Fundamentals of Groundwater*. John Willey and Sons.
- Vickers, A. 2001. *Handbook of Water Use and Conservation*. Water Plow Press.

SEMESTER VII

CORE PAPER 15: ENVIRONMENTAL ISSUES AND HUMAN HEALTH

Code: EVST15

Unit 1: Introduction

Contemporary and emerging environmental issues of local, regional and global significance I: Linkage between population, development & environment and climate change.

Unit 2: Contemporary and emerging environmental issues

Contemporary and emerging environmental issues of local, regional and global significance II: stratospheric Ozone depletion, water resources, environmental toxicants & human health, biodiversity conservation and environmental episodic events etc.

Unit 3: Global Environmental Change, impacts and remedies

Tools for mitigating global warming and climate change impacts: international agreements and protocols. The role of UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD) and REDD+ and Clean Development Mechanism (CDM). Methods for carbon footprint analysis. Critical analysis of IPCC assessment reports. Solutions: Negative emissions technologies (NET), Adaptation, mitigation with renewable energy, green building, energy efficiency and reducing consumption, the Smart Grid, distributed generation and low-tech, clean coal, nuclear power and geo-engineering.

Unit 4: Principle of environmental health

Basic principle of environmental health: Physiological responses of man to relevant stresses in the environment, cases and effects of pollution. Industrial Toxicology study of environmental dose effect relationships. Evaluation of toxicity and threshold limits. Principles and methods of occupational health. The relationship between occupation, hygiene, safety and disease.

Unit 5: Human health and safety

Health maintenance: Survey, analysis and recommendations regarding health and safety problems in the working and living environment. Treatment of variation, with demographic, vital statistics and epidemiological data. Hazard evaluation in polluted environment with specific emphasis on radiological health,emerging health risks due to climate change, vector-borne diseases, case studies on the health impacts of environmental disasters and environmental toxicology

Practical: Based on the theory

Suggested Readings

- Global Environmental Issues - Ed. Frances Harris and Frances Harris
- Global Environmental Issues - K. Jagamohan Reddy
- Global Environmental and Pollution Issues by Dr. Aaradhana Salpekar and Dr. Kadambari Sharma
- The Global Casino: An Introduction to Environmental Issues, Fourth Edition -Nick Middleton
- Global Environmental Change: The Threat to Human Health Occupational Health G. French

CORE PAPER 16: INSTRUMENTATION AND ANALYTICAL TECHNIQUES

Code: EVST16

Unit 1: Fundamentals and Instrumentation in Environmental Science

Requirement of analytical techniques to study the environmental sciences, outline of some basic and advance techniques used in environmental sciences. Basic Terminology: Equivalent weight of an acids and bases, Normality, Molarity, Molality, Specific weight, Buffer solution. Precision and accuracy. Instrumental Methods for Analysis.

Unit 2: Fundamentals of Spectroscopy

Concept, Electromagnetic spectrum, Quantum theory, Beer-lambert law. Instrumentations: Theory, Principles, Working operation and application of Colourimetry, Flame photometry, Polarimetry, Spectrophotometry: Atomic Absorption Spectroscopy, Fourier Transform Infra-Red spectroscopy, Gamma Spectroscopy, Liquid chromatography–mass spectrometry, Gas chromatography–Mass Spectrometry, InfraRed Spectroscopy,

Unit 3: Advanced Microscopy and Analytical Techniques in Environmental Science

Microscopy- Different types of Microscopes light, fluorescence, phase contrast microscopes, Electron Microscopy: Scanning and Transmission electron microscopes, Electrophoresis, solid and liquid scintillation, X-ray florescence, X-ray diffraction, auto radiography, Ultracentrifugation

Unit 4: Chromatographic and Bioinstrumentation Techniques

Chromatographic techniques (Paper chromatography, thin layer chromatography, ion exchange chromatography, Column chromatography), Gas-Liquid-Chromatography, functioning of Gas chromatograph, High pressure liquid chromatography, (HPLC), GC-MS. Bioinstrumentations: Biosensors, Electrophoresis, Gel electrophoresis, Polymerase chain

reaction, conventional microscopy, Bioreactors. Green methodology in labs.

Unit 5: Environmental Sample Processing and Analysis

Methods for processing and analysis of Environmental Samples- techniques and applications Environmental sampling: Air, Water, Soil-collection, preservation, storage and analysis of samples,open-source data analysis tools for environmental research

Practical: Based on the theory

Recommended books

1. Skoog, D.A., Holler, F., Crouch, S.R., Instrumental Analysis, Cenage Learning India Pvt. Ltd, New Delhi, 2007
2. Settle, F. Instrumental Techniques for Analytical Chemistry, Prentice-Hall, Inc., Englewood Cliffs, NJ, (1997).
3. Popek, E. P. Sampling and analysis of environmental pollutants: a complete guide, USA: Academic (2003).
4. Lillesand, T., Kiefer, R. W., & Chipman, J. Remote sensing and image interpretation. John Wiley & Sons, (2014)
5. Handbook of Thin-Layer Chromatography, 2003. 3rd Edition; Edited By Joseph Sherma, Bernard Fried. CRC Press

CORE PAPER 17: ENVIRONMENTAL ETHICS AND INTELLECTUAL PROPERTY RIGHTS (IPRs)

Code: EVST17

UNIT 1: Introduction to Environmental Ethics

Nature and Scope of Environmental Ethics; Basic Concepts and Issues, Methods of Environmental Ethics, climate ethics and the role of IPR in climate technology dissemination,

UNIT 2: Nature, Man and Society

Moral Theories and Anthropocentrism, Plea for Non-Anthropocentrism; Climate Change: Meaning, Causes and Preventions, Ecocentrism, Biocentrism, Individualism, and Animals

UNIT 3: Intellectual Property Rights (IPR)

Origin, Development and Objectives, Classification of Intellectual Property Patents, Copyright, Trademark, Industrial Design, Geographical Indications, Protection of Plant Varieties and Traditional Knowledge

UNIT 4: Laws and Legislations

International Conventions relating to Intellectual Property. General Agreement on Trade and

Tariff (GATT),Trade Related Aspects of Intellectual Property Rights (TRIPS); Establishment of WIPO Indian IPR legislations - National Intellectual Property Policy and Unfair Competition

UNIT 5: Bio-ethics and Bio-piracy

Bioethics in Plants, Animals and Microbial Genetic Engineering, Application of IPR regime to Biological Resources and Bio-piracy, Access to Biological Resources, Benefit Sharing and Informed Consent, Sustainable Development and Environment, ethical dilemmas in environmental science, such as bioethics in conservation and biotechnology

Practical: Based on the theory

Suggested Readings

- Ahuja, V.K., Law Relating to Intellectual Property Rights, 3rd Ed. Lexis Nexis.
- Cornish, W. R., Intellectual Property (Latest Edition).
- Intellectual Property Rights by Paul Goldstein.
- Kilner, John, et.al, eds., Cutting-Edge Bioethics. Eerdmans 2002.
- B.L.Wadera, Patents, Trademarks, Copyright, Designs and Geographical Indications.
- S. Ignacimuthu, Bioethics, Alpha Science International, Limited (2009).
- Arthur L. Caplan, Robert Arp, Contemporary Issues in Bioethics (2014).
- 8. Nuffield Council on Bioethics (2002), The Ethics of Patenting DNA, A Discussion Paper, London: Nuffield Council on Bioethics.

CORE PAPER 18: ENVIRONMENTAL STATISTICS

Code: EVST18

Unit 1: Basics of statistics

Population and samples, tabulation of data, concept of measures of central tendency i.e. mean, mode and median; concept of measures of dispersions like variance and standard deviation, interquartile range.

Unit 2: Comparison of population mean

Concept of sampling and its types; Correlation and regression, concept of probability, hypothesis testing and level of significance; Chi-square test, student's t-test, ANOVA and F-test.

Unit 3: Environmental System analysis and modelling

Introduction to Environmental System analysis, approaches to development of models, linear,

simple and multiple regression model, validation and forecasting, weather forecasting, spatial statistics and modeling techniques for environmental data

Unit 4: Application of modelling

Models of population growth and interactions –Lotka – Volterra model, Leslie's matrix model, point source stream pollution model, Gaussian plume model, prey-predator model.

Unit 5: Statistical programs

Computer applications: Structure, function, capabilities and limitations of computer, computer packages, applications of computer in environmental science; Ecological modeling using computer softwares, Software for statistical analysis like MS-Excel, SPSS, MiniTab, Sigmaplot, Statistica.data visualization and GIS-based statistical analysis

Practical: Based on the theory

Recommended books:

- Fundamental of applied statistics – S.C. Gupta and V.K. Kapoor
- Elements of statistics – Donald R. Byrkit.
- Multivariance analysis- Hunt and Shelly
- Computer – Newman Ed.
- Computerized environmental modeling – J. Hardstay, D.M. Tailor & S.E. Metcalf
- Computerized aided environmental management – S.A. Abbassi and F.I. Khan.
- Biostatistics M.P. Arora & P K Malhan Himalya publication
- Principle of biostatistics Satguru Prasad

MINOR PAPER 7: HUMAN-WILDLIFE CONFLICT & MANAGEMENT

Code: EVSMT07

Unit 1: Basis of conflicts

Concepts of development and encroachment, who is the intruders: human or animal? Man Wildlife conflict; issues faced all over the world. Issues faced with context to India. Impact of conflict on humans and wildlife, the impact of habitat fragmentation, social inequality in terms of forest conservation: forest produces as a need vs. forest exploitation, Increasing anthropogenic pressure on nature; Urbanisation and industrialization.

Unit 2: Wildlife conflicts and management

Insight into the important 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. Need of environmental management; wildlife conservation: moral obligation? philosophy of wildlife management; why is it necessary to worry about human wildlife conflicts? role of government, wildlife biologists and social scientists, concept of deep and shallow ecology. 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.

Unit 3: Wildlife management and 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

Suggested Readings

- 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.
- 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.

SEMESTER VIII (BSc Hon. & BSc Hon. with research)

CORE PAPER 19: RESEARCH METHODOLOGY AND DATA ANALYSIS

Code: EVST19

Unit I: An Overview of Research Methodology

Research concept, Components of research work, research problem, justification, hypothesis; literature collection- textual and digital resources, Research process, Types of Research: Fundamental, Pure or Theoretical Research, Applied Research, Descriptive Research, Evaluation Research, Experimental Research, Survey Research, Qualitative Research, Quantitative Research, Historical Research.

Unit II: Research Design, Data Collection & Interpretation

Research/Experiment design; sampling techniques, data collection and documentation, presentation, analysis and interpretation of data. Data Collection methods, primary and secondary data, Construction of questionnaire and instrument

Unit III: Statistical analysis of data

Elementary Biostatistics: Standard deviation/error; Correlation coefficient, types of correlation, regression equation, biological significance of correlation and regression; Test of significance, chi-square test, analysis of variance.systematic reviews, and data mining

Unit IV: Scientific Writing/Research Publication

Forms of scientific writing- Articles, notes, reports, review articles, monographs, dissertations,
popular science articles, bibliographies, scientific writing tools and research dissemination strategies (e.g., blogs, social media for science)

Unit V: Formulation of Scientific Communication

Outline preparation, drafting title, subtitles, tables, illustrations; Formatting tables- title, body footnotes; figures & graphs- structure, title and legends, Impact factor, citation indices, ethics in research: plagiarism,

Unit VI: Computer applications in biological research

MS office, excel, power point, graphics (Sigma plot), statistical software (SPSS).

Practical: Based on the theory

Suggested Readings

- Cooper, D.R., Schindler, P.S. and Sun, J., 2006. Business research methods (Vol. 9). New York: McGraw-Hill Irwin.
- Creswell, J.W. and Creswell, J.D., 2017. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
- Krishnaswamy, K.N., 2006. Management Research Methodology: Integration of Principles, Methods and Techniques. Pearson Education India.
- Sekaran, U. and Bougie, R., 2016. Research methods for business: A skill building approach. John Wiley & Sons.
- Business Research Methods- Alan Bryman & Emma Bell, Oxford University Press.
- Kothari, C.R. & Garg, G. (2019). Research Methodology: Methods and Techniques. New Age International Publishers, New Delhi.

CORE PAPER 20: ENVIRONMENTAL HAZARDS: CONCEPT AND MANAGEMENT

Code: EVST20

Unit 1: Introduction

Definition of hazard; natural, technological, and context hazards; concept of risk and vulnerability; reasons of vulnerability - rapid population growth, urban expansion, environmental pollution, epidemics, industrial accidents, inadequate government policies

Unit 2: Natural hazards

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 3: 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 4: Risk and vulnerability assessment

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, disaster risk reduction frameworks, including climate risk mitigation

Unit 5: Mitigation and preparedness

Concept of mitigation; types of mitigation: structural and non-structural mitigation, use of technologies in mitigations such as barrier, deflection and retention systems; concept of preparedness; importance of planning, exercise, and training in preparedness; role of public, education and media in hazard preparedness.

Unit 6: 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. GIS-based hazard mapping and community-based disaster preparedness projects

Practical: Based on the theory.

Suggested Readings

- 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.
- 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*. 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.

CORE PAPER 21: ENVIRONMENTAL ECONOMICS

Code: EVST21

Unit 1: Introduction

Concept of environmental economics, the economy and the environmental, cost effectiveness analysis, cost-benefit analysis.

Unit 2: National Resource Economics

National resource economics- analytical tools, supply and demand, accountings of naturals assets.

Unit 3: Pollution Economics

Pollution economics- Environmental policy analysis, command control strategies and incentive based strategies, economic valuation techniques of environmental benefits assets.

Unit 4: Carbon Economics

Terminology- Carbon tax, carbon foot print assessment, carbon trading, clean development mechanism, clean production and technology and eco-mark.

Unit 5: Natural Resource Accounting

Natural resources accounting – concepts, methods and empirical evidences. Environment and trade. Prey-Predator and supply-demand cycles

Practical: Based on the theory.

Suggested Readings

- Baumol and Oates, 1988, Theory of Environmental Policies, Cambridge University Press, Cambridge, UK.
- Freeman A.M., 2001, Measures of value and Resources: Resources for the future, Washington DC.
- Shogren, White and Hanley, 2001, Introduction to Environmental Economics, Oxford University Press, New York.
- Tietenberg. T, 2003, Environmental and Natural Resource Economics. Pearson Education, New York.
- Kumar Pushpam, 2005, Economics of Environment and Development. Arc Books New Delhi.
- Baumol, W.J. and Oates, W.E., 1988, The Theory of Environmental Policy Cambridge University Press.
- Bhattacharya, R.N. (Ed.), 2001, Environmental Economics: An Indian Perspective, O.U.P.
- Bromley, D.W. (Ed.), 1995, Handbook of Environmental Economics, Blackwell.
- Kadekodi, G.K., (Ed.), 2004, Environmental Economics & Practice, O.U.P.
- Kolstad, Charles, 2000, Environmental Economics, Oxford University Press.

CORE PAPER 22: LABORATORY GUIDANCE AND SAFETY

Code: EVST22

Unit 1: Basic Rules

Basic laboratory manners, Common-Sense Rules, Good Laboratory Practices, Experimental Data Recording, Possible laboratory hazards

Unit 2: Safety Measures

Types of danger omnipresent in labs, Safety, Security and Risk assessment, Handling dangerous equipments, Accident by reagents
First-aid: Acid burns, Alkali burns, External injury, Procedures after the first aid

Unit 3: Lab-ware & Chemical Management

Search, order and stock of lab ware and chemical, Common vs private, Record usage record, Disposal of depleted chemicals, Handling of high-pressured gas, Classification of dangerous chemicals, Chemical regulations by laws

Unit 4: Instrument Management

- Development of instrument management system
- Importance of labo-seminar and information
- Maintenance of instruments
- Importance of instrument calibration
- Limit of Detection (LOD)
- Limit of Quantification (LOQ)

Unit 5: Preparing for Experiments

- Basic preparation to start an experiment
- Mistakes while weighing, pipetting and taking reading
- Preparation of standard and stock solution
- Care while doing experiments
- Glass wares management before and after an experiment

Unit 6: Experimental Waste Management and Regulations

- Types of experimental waste
- Classification of hazardous wastewater
- Handling unknown chemicals

- Material Safety Data Sheet (MSDS)
- Pollutant Release and Transfer Register (PRTR)

Practical: Based on the theory.

Suggested Readings

- G.H. Jeffery, J.Bassett, J. Mendham, R.C. Denny, Textbook of quantitative chemical analysis, John Wiley & Sons, 1998.
- A.Keith Furr, Handbook of Laboratory Safety, CRC Press, 5th edition, 2000.
- P. Patnaik, Analytical Chemistry Handbook, McGraw-Hill, 2004
- J. Cazes, Analytical instrumentation Handbook, CRC Press, 2005.
- Margaret-Ann Armour, Hazardous Laboratory Chemicals Disposal Guide, CRC Press, 3rd edition, 2003.

MINOR PAPER 8: MODERN TOOLS AND TECHNOLOGIES IN ENVIRONMENTAL MANAGEMENT

Code: EVSMT08

Unit 1: Remote Sensing and GIS

Remote Sensing, Application of Remote Sensing in Managing Environment, Statistical Parameters of Remote Sensing, and Mathematical Modeling with modeling and calculations of High-Tech Monitoring Tools and software related to Environment Management, Geographical Information Systems - Concepts, Use in Environment Management Applications, GIS- Ground Water, Watershed Wetland, Water Quality Applications

Unit 2: Modern technologies for a sustainable future

Carbon footprint, water footprint, Ecological footprint, clean development mechanism, Carbon Capture and Storage (CCS) technology, Solar Glass in improve global energy sustainability, Environmental Sensors

Unit 3: Environmental Management Tools

Environmental risk assessment (ERA), Environmental impact assessment (EIA), Environmental Monitoring and Audits (EMA), Environmental Management Systems (EMS), Strategic environmental assessment (SEA)

Suggested Readings

- 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.
- Marriott, B. 1997. *Environmental Impact Assessment: A Practical Guide*. McGraw-Hill, New York, USA
- A. Ganesh. (2006). Application of Geospatial Technology. Satish Serial Pub. House, Delhi.
- Burrough PA. 1990. *Principles of GIS for Land Resources Assessment*. Oxford & IBH.
- Chouhan, T.S. and Joshi, K.N. (1992). Remote Sensing for Natural Resources Management. Universal Scientific Publication, Jaipur.
- Colwell, Robert W. (1971). Monitoring of Earth Resources from Aircraft and Spacecraft, NASA. Washington D.C.

GENERIC ELECTIVE 1: BIOINDICATORS AND ECOREMEDIATION

Code: EVSGE01

UNIT-1

IntroductionandconceptofEcoremediation,indicatorsandmarkerssignificanceofremediationfo recologicalhealth.Ecoremediationis an option to treat contaminated soils and groundwater.Advantages anddisadvantagesoftheprocess.

UNIT-2

Monitoring and management of bioindicators – Identification of representative indicatorsforvariousecosystem/habitat.Toolsandtechniquesformonitoringofbioindicators.Ma nagementofbioindicators:Casestudies.

UNIT-3

Composting,majortypes:Open-airsystems,enclosedsystems,advantages,Vermicomposting:earthwormbiologyandphysiology ,endproducts,process,andcharacteristics.

UNIT-4

Bioremediation,typesofbioremediation,advantagesanddisadvantagesofbioremediationcompa red to nonbiological processes, intrinsic and accelerated bioremediation; case studies. In situandExsitubioremediation;mineralizationvs.partialdegradation.BioremediationofVOCs.Bi odegradationofaromaticandpolyaromatichydrocarbons,polychlorinatedbiphenyls.Heavymeta landoilspill bioremediation,contaminated soiland groundwater remediation.

UNIT-5

Phytoremediation, technical characteristics, types of phytoremediation, factors influencingphytoremediation,advantagesanddisadvantagesofphytoremediation,case studies.ReclamationofContaminatedSites - Casestudies,MinesiterehabilitationinIndia,Plantsused for dual benefits: Canola case studies for phytoremediation and biofortification in California,

Suggested Readings

- Shahnawaz,M.;Sangale,M.K.;Ade,A.B.,2019.BioremediationTechnologyforPlasticWaste.
- AjaySingh,OwenPWard,1999AppliedBioremediationandPhytoremediationSpringer,NewYork.
- Varjani,S.J.(Ed),Agarwal,A.K.(Ed),Gnansounou,E.(Ed),Gurunathan,B.(Ed),2018.Bioremediation:Applications forEnvironmental Protectionand Management.
- WilliamChang(Ed),2017.BiodegradationandBioremediation.SyrawoodPublishingHouse.
- Singh&Tripathi.Springer,2007.Environmental BioremediationTechnologies.
- AtlasRM,BarthaR2000.MicrobialEcology,PearsonEducation,Singapore.
- AlexanderMartin1999. BioremediationandBiodegradation,AcademicPress,NewYork.

GENERIC ELECTIVE 2:GENDER AND ENVIRONMENT

Code: EVSGE02

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 and environmental management

Women's participation in environmental movements and conservation; historical and contemporary case studies; role of women in environmental education, awareness and sustainable development.

Unit 5: Strategies for change

Need for gender equity; Instruments for change: education, media, action groups, policy and

management; equity in resource availability and consumption for a sustainable future.

Practicals: Tutorial based course.

Suggested Readings

1. Agarwal, B. 1992. *The Gender and Environment Debate: Lessons from India*. Feminist Studies)Minnesota(.
2. Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations andTemporal Shifts in Rural India: 1971-1991. *World Development***25:** 1-42.
3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for
4. South Asia and a conceptual framework. *World Development***29:** 1623-1648.
5. Krishna, S. 2004. *Livelihood and Gender*. New Delhi, Sage.
6. Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion roseand fell. *Development and Change***38:** 67-85.
7. Miller, B. 1993. *Sex and Gender Hierarchies*. Cambridge University Press
8. Stein, R.)ed.(. 2004. *New Perspectives on Environmental Justice: Gender, Sexuality, andActivism*. Rutgers University Press.
9. Steingraber, S. 1998. *Living Downstream: A Scientist's Personal Investigation of Cancer andthe Environment.* New York: Vintage Books.
10. Zwarteveen, M.Z. 1995. *Linking women to the main canal: Gender and irrigationmanagement*. Gatekeeper Series 54, IIED.

GENERIC ELECTIVE 3:SYSTEMATICS AND BIOGEOGRAPHY

Code: EVSGE03

Unit 1: systematics and Taxonomic hierarchy

Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; nomenclature; taxonomy databases, Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy

Unit 2: Systems of classification and nomenclature

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, Numerical and molecular systematics**,** DNA barcoding; phylogenetic tree (rooted,unrooted, ultrametric trees)

Unit 3: Introduction to Biogeography

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.

Unit 4: Speciation and extinction

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 5: Ecological Biogeography

Species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; geography of diversification and invasion; phylogeography.

Practicals: Based on the theory.

Suggested Readings

1. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. *Biogeography*)4th edition(. Sinauer Associates, Sunderland.
2. Mani, M.S. 1974. *Ecology and Biogeography in India*. Dr. W Junk Publishers., The Hague.
3. Singh, G. 2012. *Plant Systematics: Theory and Practice*)3rd edition(. Oxford & IBH Pvt. Ltd., New Delhi.
4. Wheeler, Q.D. & Meier R. 2000. *Species Concepts and Phylogenetic Theory: A Debate.* Columbia University Press, New York.
5. Williams, D. M., Ebach, M.C. 2008. *Foundations of Systematics and Biogeography*. Springer.
6. Wilkins, J. S. 2009. *Species: A History of the Idea*)Vol. 1(. University of California Press.

GENERIC ELECTIVE 4:RENEWABLE ENERGY

Code: EVSGE04

Unit 1: Wind energy - Wind energy resources, power in wind, wind turbine design considerations,grid connected wind farms, hybrid power systems, economics of wind power systems, economicanalysismethods,windenergyconversionsystem.

Unit 2: Solar energy – Introduction, Earth's orbit, solar constant and solar spectra, solar angles,collectorangles,solarirradiance,photovoltaicenergyconversion,typesofphotovoltaicsystems;solarthermalelectricpowerplant -solarthermalsystems,environmentalimpact.

Unit 3: Bio Fuels – Biomass as a source energy, types of biomass, energy content of biomass,harvesting methods of biomass, conversion of biomass, thermos-chemical conversion of biomass,biodieselproduction,bioethanolproduction**,**forestbiomassproduction,forestspecies,environmentalimpactresultingfromthe generationand exploitationofforestbiomass.

Unit 4: Ocean and Small hydro energy systems – Marine energy, understanding the power ofmarineenergy,globaldevelopmentofmarineenergy,oceanwaveenergy,oceantideenergy,mathematical modelling of tidal schemes, global environmental impact; low power hydro plants,microhydroplants.

Unit 5: Energyplanningforrenewableenergysystems- Modernpowerelectronictechnologyforrenewableenergysources,futuretrendsinwind-powertechnology,powerelectronicsinphotovoltaicsystems, recent trends in energy storage technologies, power quality instrumentation, regulatoryframework,energyresourceallocation,regiondependentdevelopmentinenergyplanning

Practicals: Based on the theory.

Suggested Readings

1. Buchla,DM,KissellTEandFloydTL,2017,RenewableEnergySystems,PearsonEducation.
2. Zobaa,AFandBansal,RC,2011HandbookofRenewableEnergyTechnology,WorldScientificPublishing Co.Pte.Ltd. Singapore.
3. Boyle,2012,RenewableEnergy:PowerforaSustainableFuture,OxfordUniversityPress,3rdEdition.
4. Renewables2005:GlobalStatusReport:NotesandReferencesCcompanionDocument,REN21NetworkReport,2005
5. Khan,2017,Non-ConventionalEnergyResources,McGrawHillEducation,IndiaPvtLtd.