B.Sc with Environmental Science (Minor)
WBSU (NEP)
Credit hours: 3+2

SEM 1: ECOLOGY AND ECOSYSTEMS
(Credits: Theory-3)
Theory (45 Lectures)

Unit 1: Introduction (15 lectures)

Basic concepts and definitions: ecology, landscape, habitat, biomes, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals. primary production and secondary production; models of energy flow; food chain, food web; detritus pathway of energy flow and decomposition processes; ecological pyramids: pyramids of number, biomass, and energy.

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Unit 2: Ecology of populations and communities (15 lectures)

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, community structure and organization: physiognomy, sociability, species associations, periodicity, biomass,stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: primary and secondary successions, models and types of successions, climax community concepts, examples of succession.

Unit 3: Ecosystem ecology and Biogeochemical cycles (15 lectures)

Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; 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 mycorrhiza; nutrient use efficiency; nutrient budget; nutrient conservation strategies. Concept of exotics and invasives; stages of invasion; mechanisms of invasions; invasivepathways; impacts of invasion on ecosystem and communities; economic costs of biological invasions.

Practicals: (Credits: Practicals-2)

1. Qualitative and quantitative analysis of planktons of aquatic systems.
2. Determination of species, dominance and frequency using quadrate/ plot method.
3. Ecological field visit: pond/forest/river/wetland or other ecosystem.

Suggested Readings
1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21stCentury. 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.BioScience35: 700-706

SEM 2: ENVIRONMENTAL BIOTECHNOLOGY
(Credits: Theory-3)
Theory (45 Lectures)

Unit 1: The Structure and Function of nucleic acid (15 lectures)

DNA: structural forms and their characteristics (B, A, C, D, T, Z); physicalproperties: UV absorption spectra, denaturation and renaturation kinetics;biological significance of different forms; Synthesis.RNA: structural forms and their characteristics (rRNA, mRNA, tRNA); biological significance of different types of RNA; synthesis. Protein: hierarchical structure (primary, secondary, tertiary, quaternary), types of amino acids; Central dogma of biology; genetic material of prokaryotes, viruses, eukaryotes and organelles; mobile DNA

Unit 2: Recombinant DNA Technology (15 lectures)

Recombinant DNA: origin and current status; steps of preparation; toolkit ofenzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNApolymerases, transferase, reversetranscriptase), other DNA modifying enzymes (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes; nucleic acid, microarrays).

Unit 3: Ecological restoration and bioremediation (15 lectures)

Wastewater treatment: domestic and industrial, methanogenesis, bioreactors,solid waste treatment: sources and management (composting, vermiculture and methane production, landfill, hazardous

waste treatment); bioremediation: ex-situ & in-situ, specific bioremediation technologies: bioaugmentation, bioventing, biosparging, phytoremediation: advantages and disadvantages; degradation of xenobiotics in environment, surfactants, pesticides, heavy metals degradative pathways. PGPR bacteria: biofertilizers, Integrated Pest Management; development of stress tolerant plants, biofuel.

Practical: (Credits: Practicals-2)

1. Gram Staining, coliform count (MPN)
2. Estimation of Water Quality Parameters (DO, BOD, COD)
3. Viva voce

Suggested Readings

1. Evans, G.G. & Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2ndedition). 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 and Applications. 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.

SEM 3: URBAN ECOSYSTEMS AND ENVIRONMENTAL POLLUTION
(Credits: Theory-3)
Theory (45 Lectures)

Unit 1: Air pollution (15 lectures)

Definition of pollution; pollutants; classification of pollutants.Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; smog (case study); effects of different pollutants on human health (NOx, SOx, PM, CO, CO2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health, Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); 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; control measures.

Unit 2: Soil and Water pollution (15 lectures)

Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms.Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides), Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management.

Unit 3: Pollution management in urban settings (15 lectures)

Introduction to urbanization; urban sprawl and associated environmental issues; commodification of nature; metros, Cities, Benefits of environmental management; introduction to green buildings; urban governance; smart cities; regulatory framework for pollution monitoring and control: Water (prevention and control of) Pollution Act, 1974, Air (Prevention and Control of) Pollution Act, 1981, Environmental Protection Act, 1986; case study: Ganga Action Plan;Yamuna Action Plan; implementation of CNG in NCT of Delhi.

Practical: (Credits: Practicals-2)

1. Estimation of soil parameters: pH & Temperature; Soil Organic carbon.
2. Monitoring of air quality parameters (NOx, SOx, SPM) and Noise (Leq) .
3. Field visit to effluent treatment plants (ETP)/ sewage treatment plants (STP).

Suggested Readings :

1. D'Monte, Darryl. 1985. Industry versus Environment Temples or Tombs. Three Controversies, Delhi, CSE.
2. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
3. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science 319:756-760.
4. 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.
5. Montgomery, M.R. 2009. Urban Transformation of the developing world.
Science 319: 761-764.
6. Richter, M. & Weiland, U. (ed.). 2012. Applied Urban Ecology. Wiley- Blackwell, UK.
7. Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. Air Pollution: Health and Environmental Impacts. CRC Press, Taylor & Francis.
8. Hester, R.E. & Harrison, R.M. 1998. Air Pollution and Health.The Royal Society of Chemistry, UK.
9. Park, K. 2015. Park's Textbook of Preventive and Social Medicine (23rd edition).Banarsidas Bhanot Publishers.
10. Pepper, I.L., Gerba, C.P. &Brusseau, M.L. 2006. Environmental and Pollution Science. Elsevier Academic Press.
11. Purohit, S.S. &Ranjan, R. 2007. Ecology, Environment & Pollution.Agrobios Publications.
12. Vesilind, P.J., Peirce, J.J., & Weiner R.F. 1990. Environmental Pollution and Control. Butterworth-Heinemann, USA.

SEM 4: BIODIVERSITY AND CONSERVATION
(Credits: Theory-3)
Theory (45 Lectures)

Unit 1: Levels of organization, patterns and estimation of biodiversity (15 lectures)

From genes to ecosystems; tree of life; history of character transformation; species concept; concept and types of speciation.
Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation.
Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity

Unit 2: Biodiversity of India: Importance and threats (15 lectures)

India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; fish and fisheries of India;
Economic values – medicinal plants, drugs, social, aesthetic, consumptive, and ethical values of biodiversity.
Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; IUCN Red List categorization – guidelines, practice and application; Red Data Book; Intermediate Disturbance Hypothesis.

Unit 3: Status of biodiversity conservation in India (15 lectures)

In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation(botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), status of protected areas and biosphere reserves in the country;
role of local communities and traditional knowledge in conservation; biodiversity hotspots; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources, National Biodiversity Action Plan.

Practicals: (Credits: Practicals-2)

1. Estimation of floral Biodiversity parameters and indices: Frequency, Density, abundance, Relative abundance,
2. Calculation of indices: Shannon Weiner's index, Simpson's index of diversity.

3. Estimation of insect diversity : pitfall and trap

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.

SEM 5: ENERGY AND ENVIRONMENT
Credits: (Theory-3)
Theory (45Lectures)

Unit 1: Introduction (15 lectures)

Defining energy; forms and importance; energy use from a historical perspective;
energy over-consumption in urban setting; Global energy resources; renewable and non-renewable resources: distribution and availability; energy-use scenarios in rural and urban setups; energy conservation; Global energy demand: historical and current perspective; energy demand and use
in domestic, industrial, agriculture and transportation sector;
energy subsidies and environmental costs.

Unit 2: Energy, environment and society (15 lectures)

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

Unit 3: Energy policy and future(15 lectures)

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

Practicals: (Credits: Practicals-2)

1. Calculation of energy efficiency from given data.
2. Preparation of energy audit of a domestic/ Institutional unit and report submission.

Suggested Readings

1. McKibben, B. 2012. Global Warming's Terrifying New Math, Rolling Stone Magazine.
2. 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.
3. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.
4. Rowlands, I.H. 2009. Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies in Debora L. Van Nijnatten and Robert Boardman (eds.), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.
5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.
6. Mallon, K. 2006. Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making. Earth Scan.

SEM 6: NATURAL HAZARDS AND DISASTER MANAGEMENT

Credits: (Theory-3)
Theory (25 Lectures)

Unit 1: Natural hazards (15 lectures)

Definition of hazard; natural, technological, and context hazards; concept of risk and vulnerability; Two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); reasons of vulnerability 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 tsunamiscoastal erosion, sea level changes and its impact on coastal areas.

Unit 2: Anthropogenic hazards (15 lectures)

Impacts of anthropogenic activities such as rapid urbanization and population growth, pollution, epidemics, injudicious ground water extraction, sand mining from river bank, deforestation, mangroves destruction; role of construction along riverbanks 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; inadequate Government Policies. Case Studies: Minamata and Chernobyl disaster, Bhopal Gas tragedy

Unit 3: Risk and vulnerability assessment and mitigation measures(15 lectures)

Application of geoinformatics in hazard, risk & vulnerability assessment.
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; Lessons from the past:Tsunami in 2004 and Bhuj earthquake; 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 studies: COVID-19 and Cyclone Amphan (2020)

Practicals: (Credits: Practicals-2)

1. Preparation of disaster management plan and its presentation.
2. Viva voce

SuggestedReadings:

1. CoppolaD.P.2007.*IntroductiontoInternationalDisasterManagement*.ButterworthHeinemann.
2. Cutter,S.L.2012.*HazardsVulnerabilityandEnvironmentalJustice*.EarthScan,RoutledgePress.
3. Keller,E.A.1996.*IntroductiontoEnvironmentalGeology*.PrenticeHall,UpperSaddleRiver,NewJersey.
4. Pine,J.C.2009.*NaturalHazardsAnalysis:ReducingtheImpactofDisasters*.CRCPress,TaylorandFrancisGroup.

5. Schneid,T.D.&Collins,L.2001.*DisasterManagementandPreparedness*.LewisPublishers,NewYork,NY.
6. Smith,K.2001.*Environmental Hazards:AssessingRiskandReducing Disaster*.RoutledgePress.
7. Wallace,J.M.&Hobbs,P.V.1977.*AtmosphericScience:AnIntroductorySurvey*.AcademicPress,NewYork.
8. Wasson,R.J.,Sundriyal,Y.P.,Chaudhary,S.,Jaiswal,M.K.,Morthekai,P.,Sati, S.P.&Juyal,N.2013.A1000-yearhistoryoflargefloodsintheupperGangacatchment,centralHimalaya,India.*QuaternaryScienceReviews***77**:156–166.

SEM 7: SPECIAL MINOR (SM)
SOLID WASTE MANAGEMENT
Credits: (Theory-3)
Theory (45 Lectures)

Unit 1: Basics of Solid Waste Management (15 lectures)

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste; Municipal solid waste management: composition; segregation of MSW, onsite disposal; open dumps; sanitary landfills; environmental consequences; Management of Bio-medical waste: disposal and treatments; Health consequences. E-waste management: generation; segregation; disposal and treatments; Environmental impacts.
Hazardous waste management: Definition, identification and classification of hazardous waste; Treatment Technologies
Industrial waste management (6 lectures): Effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring

Unit 2: Waste minimization techniques (15 lectures)

5R - reduce, reuse, recycle, recovery and residual management; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment. Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification. Value added products from waste; Fly ash utilization and disposal Garbage farming; Sewage fed fisheries; Composting.

Unit 3: Integrated waste management and policies (15 lectures)

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.Municipal Solid Wastes (Management and Handling) Rules 2000; Solid Waste Management Rules, 2016, Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998, 2016; Plastic Waste (Management and

Handling) Rules, 2011; E-Waste (Management) Rules, 2016

Practicals: (Credits: Practicals-2)

1. VisittoaWasteManagementsiteandReportsubmission.

2.Viva-voce

SuggestedReadings

1. Asnani,P.U.2006.Solidwastemanagement.*IndiaInfrastructureReport570*.
2. Bagchi,A.2004.*DesignofLandfillsandIntegratedSolid WasteManagement*.JohnWiley&Sons.
3. Blackman,W.C.2001.*BasicHazardousWasteManagement*. CRCPress.
4. McDougall,F.R.,White,P.R.,Franke,M.,&Hindle,P.2008.*IntegratedSolidWaste Management:ALifeCycleInventory*.JohnWiley& Sons.
5. USEPA.1999.*GuideforIndustrialWasteManagement*. WashingtonD.C.
6. White,P.R.,Franke,M.&Hindle P.1995. *IntegratedSolidwasteManagement:ALifecycleInventory*.BlackieAcademic&Professionals.
7. Zhu,D.,Asnani,P.U.,Zurbrugg,C.,Anapolsky,S.&Mani,S.2008.*ImprovingMunicipalSolidwasteManagementinIndia*.TheWorldBank, WashingtonD.C.

SEM 8: SPECIAL MINOR (SM)
ORGANISMAL AND EVOLUTIONARY BIOLOGY
Credits: (Theory-3)
Theory (25 Lectures)

Unit 1: History of life on Earth (15 lectures)

Paleontology and evolutionary History; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes;

Unit 2: Theories and evidences of evolution (15 lectures)

Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis. Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity.

Unit 3: Molecular evolution and population genetics(15 lectures)

Neutral evolution; molecular divergence and molecular clocks; molecular tools in

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

Practicals: (Credits: Practicals-2)

1. Numericalproblemsonpedigreeandpopulationgenetics.
2. Viva-voce
3. LaboratoryNotebooks

SuggestedReadings

1. Futuyma,D.J.2009.*Evolution*(2ndedition).SinauerAssociates.
2. Gillespie,J.H.1991.*TheCausesofMolecularEvolution*.OxfordUniversityPress.
3. Graur, D. & Li, W.H. 1999. *Fundamentals of Molecular Evolution* (2nd edition).SinauerAssociates.
4. Kimura,M.1984.*TheNeutralTheoryofMolecularEvolution*.CambridgeUniversity Press.
5. Minkoff, E.C.1983. *EvolutionaryBiology*.AddisonWesley.PublishingCompany.
6. Nei,M.&Kumar,S.2000.*MolecularEvolutionandPhylogenetics*.OxfordUniversity Press.
7. Nei,M.1975.*MolecularPopulationGeneticsandEvolution*.North-HollandPublishingCompany.
8. Nei,M.1987. *MolecularEvolutionaryGenetics*.ColumbiaUniversityPress.
9. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolutionof the rate of molecular evolution. *Molecular Biology and Evolution* 15: 1647-1657.

SEC 1: ENVIRONMENTAL POLLUTION AND GREEN TECHNOLOGIES
Total Credits: 3
45 Lectures

Unit 1: Air and Noise Pollution (15 lectures)

Definition of pollution; pollutants; classification of pollutants (Physical, chemical and biological).
Air borne particles and particulate matters, Temperature inversion, SOX, NOX, Hydrocarbons, Lead & other pollutants; Temperature inversion; photochemical Smog; Health effects of Air pollution; Adverse health effects of tobacco.
Measurement of Noise, Health effects of Noise pollution, Control of noise pollution.

Unit 2: Water and Pesticide pollution (15 lectures)

Sources of surface and ground water pollution; Water quality parameters: COD, BOD, DO, hardness, alkalinity; Biological aspects of water pollution: MPN, Eutrophication; Biological indicator; Arsenic pollution of drinking water and its consequence: An overview.
Classification of pesticide, Biological magnification of persistent organic pollutants.

Unit 3: Green technologies and its applications (15 lectures)

Definition and concepts: green technology, Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse; Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods; Rainwater Harvesting; Successful green technologies: wind turbines, solar panels; 3R's of green technology: recycle, renew and reduce.

Suggested Reading:

1.Anastas, P.T. & Warner, J.C. 2000. Green Chemistry: Theory & Practice. Oxford University Press

2.Arcceivala S. J. 2014. Green Technologies for better future Mcgraw Hill Publication.

3.Chapman, Reiss. Ecology: Principles and Applications. 1999. Cambridge University Press.

4.Das MC. 2009. Fundamental of Ecology (3rd Ed).Mc Graw Hill Publication.

5.De AK.2021. Environmental Chemistry (10th Ed).New Age International Publications.

6.Khopkar, S.M. 2018. Environmental Pollution Monitoring and Control (2nd Ed.). New Age International Publications.

7.Kormondy E J. 2017. Concept of Ecology (4th Ed). Pearson.

SEC 2: ENVIRONMENT AND SOCIETY

Total Credits: 3
45 Lectures

Unit 1: Environmental Literacy and Discrimination (15 lectures)

Environmental literacy (formal and non-formal education), Societal view of the environment, Environmental Ethics: Kantian and Rawlsian theories of ethics; North – south conflicts; Discrimination, inequality, Food insecurity, poverty, environmental refugees, climate change mitigation and adaptation. Gender-based violence, gender and environment debate, Ecofeminism.

Unit 2: Environmental Problems Global perspectives (15 lectures)

Classifying environmental problems, Multi-purpose river valley projects and their environmental and social impacts, social and ecological losses versus economic benefits, overpopulation; Climate negotiations.

Unit 3: Environmental movements (15 lectures)

Bishnoi Movement, Silent Valley movement, Chipko and Appiko movement, Narmada and Tehri dam movements, Johad movement, Greta Thunberg's story. JFM movement

Suggested reading

1. Environmental Ethics: A Very Short Introduction – Robin Attfield , OUP
2. A New Environmental Ethics. The Next Millennium for Life on Earth By Holmes Rolston III, Routledge; 2nd edition
3. Environmental Studies And Ethics (PB) by Suresh Gouri, I K International
4. Environmental Issues In India: A Reader by Rangarajan, Pearson India
5. Environmental Literacy: Everything You Need to Know About Saving Our Planet by Steven Dashefsky, Random House
6. Environmental Movements in India Hardcover – Import, 1 January 2005by R. B. Patil &S. N. Pawar, Rawat Pubns

SEC 3: ENVIRONMENTAL ECONOMICS AND STATISTICS

Total Credits: 3
45 Lectures

Unit 1: Concept of environmental economics (15 lectures)

Economy and the environment; Economics of non-renewable resources; economics of fuels and minerals; Introduction to natural resource accounting. Carbon tax, carbon trading; clean development mechanism; clean production and technology and ecomark - concept only.

Unit 2: Tools for environmental economic policy (15 lectures)

Growth and environment; environmental accounting, Kuznets curve, assessing benefits and cost for

environmental decision making; cost benefit analysis; Economic valuation techniques of environmental benefits - various methods; Policies for controlling air and water pollution; polluter pay principles.

Unit 3: Basic Statistics (15 lectures)

Statistical Sampling, sampling units, estimation of sample size; Mean, mode, median, standard error and deviation, probability, correlation and regression; Testing of hypothesis: Null and alternative, chi-square and student's 't' test.

Suggested Reading:

1. Banerjee P.K., 2011. Introduction to Biostatistics. S,Chand.
2. Bluman, 2007. Elementary Statistics: A step by Step Approach. Mc Grawhill.
3. Rastogi, B.B. Biostatistics. MEDTEC
4. Hanley N, Shogren J.F. & White B. Environmental Economics in Theory and Practice, Macmillan
5. Kolstad C, Environmental Economics, OUP