Distribution of the courses in different semesters for Undergraduate Course in Sciences

Semester	Core	DSE	GE	AECC	SEC	Total Credit
1.	DSC 1A DSC 2A DSC 3A			Environmental Studies		**20**
2.	DSC 1B DSC 2B DSC 3B			English/MIL Communication		**20**
3.	DSC 1C DSC 2C DSC 3C				SEC1 (ENVS SEC 1)	**20**
4.	DSC 1D DSC 2D DSC 3D				SEC2 (ENVS SEC 2)	**20**
5.		DSE1A DSE2A DSC3A			SEC3	**20**
6.		DSE1B DSE2B DSE3B			SEC4	**20**
Total number of courses	**12**	**6**	**0**	**2**	**4**	**120**

***wherever there is practical there will be no tutorials and vice -versa**

B.Sc. with Environmental Science

Core Courses:

1. **ECOLOGY AND ECOSYSTEMS (EVSHGEC01T and EVSHGEC01P) Or (EVSGCOR01T and EVSGCOR01P)**
2. **ENVIRONMENTAL BIOTECHNOLOGY (EVSHGEC02T and EVSHGE02P) or (EVSGCOR02T and EVSGCOR02P)**
3. **URBAN ECOSYSTEMS AND ENVIRONMENTAL POLLUTION (EVSHGEC03T and EVSHGE03P or EVSGCOR03T and EVSGCOR03P)**
4. **BIODIVERSITY AND CONSERVATION (EVSHGEC04T and EVSHGE04P or EVSGCOR04T and EVSGCOR04P)**

Discipline Specific Electives-

1. **ENERGY AND ENVIRONMENT (EVSDSE01T)**
2. **NATURAL HAZARDS AND DISASTER MANAGEMENT (EVSDSE02T)**
3. **SOLID WASTE MANAGEMENT (EVSDSE03T and EVSDSE03P)**
4. **ORGANINSMAL AND EVOLUTIONARY BIOLOGY (EVSDSE04T)**
   - **(Either of the DSE option can be chosen between 1 and 2 for the 5th Semester and between 3 and 4 for the 6th Semester).**

Ability Enhancement Compulsory Courses:

1. **Environmental Studies**
2. **English/MIL Communication**

Skill Enhancement Courses:

1. **BIOLOGICAL TECHNIQUES (EVSSSEC01M)**
2. **ENVIRONMENTAL MICROBIOLOGY(EVSSSEC02M)**

CORE COURSE 1: ECOLOGY AND ECOSYSTEMS
(Credits: Theory-4)
EVSHGEC01T Or EVSGCOR01T
Theory (60 Lectures)

Unit 1: Introduction (5 lectures)
Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes.

Unit 2: Ecology of individuals (10 lectures)
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.
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Unit 3: Ecology of populations (10 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; deterministic and stochastic models of population dynamics; rudreal, competitive and stress-tolerance strategies.

Unit 4: Ecology of communities (10 lectures)
Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: primary and secondary successions, models and types of successions, climax community concepts, examples of succession.

Unit 5: Ecosystem ecology (10 lectures)
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 6: Biogeochemical cycles and nutrient cycling (8 lectures)
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.

Unit 7: Biological invasions (7 lectures)
Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; invasive ecogenomics – role of polyploidy and genome size in determining invasiveness; economic costs of biological invasions.

Practicals: (Credits: Practicals-2)
EVSHGEC01P Or EVSGCOR01P

1. Qualitative and quantitative analysis of planktons of aquatic systems.
2. Determination of species, dominance and frequency using quadrate/ plot method.
3. Determination of dissolved oxygen, free carbon dioxide and primary productivity of water samples collected from aquatic ecosystems.
4. 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.*BioScience*35: 700-706

CORE COURSE 2: ENVIRONMENTAL BIOTECHNOLOGY
EVSHGEC02T Or EVSGCOR02T
(Credits: Theory-4)
Theory (60 Lectures)

Unit 1: The Structure and Function of DNA, RNA and Protein (15 lectures)

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

Unit 2: Recombinant DNA Technology (15 lectures)

Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, transferase, reversetranscriptase), other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotidekinase); genomic and cDNA libraries: construction, screening and uses; cloning and expression vectors (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes; nucleic acid, microarrays).

Unit 3: Ecological restoration and bioremediation (20 lectures)
Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein(enzyme) immobilization techniques; treatment schemes for waste water: dairy, distillery, tannery, sugar, antibiotic industries; solid waste treatment: sources and management (composting, vermiculture and methane production, landfill, hazardous waste treatment); specific bioremediation technologies: land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wetlands, use of bioreactors for bioremediation; phytoremediation; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in environment, decay behavior and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, heavy metals degradative pathways.

Unit 4: Ecologically safe products and processes (10 lectures)
PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated Pest Management; development of stress tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation and concentration of metals, metal leaching, extraction; exploitation of microbes in copper and uranium extraction.

Practical: (Credits: Practicals-2)
EVSHGEC02P Or EVSGCOR02P

a) Cytological preparation of Mitotic stages from onion root tips (*Allium cepa*)
b) Cytological preparation of Meiotic stages from grasshopper testis
c) Gram staining of bacterial sample.
d) Estimation of carbohydrate, protein and DNA.

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.

CORE COURSE 3: URBAN ECOSYSTEMS AND ENVIRONMENTAL POLLUTION
EVSHGEC03T Or EVSGCOR03T
(Credits: Theory-4)
Theory (60 Lectures)

Unit 1: Urbanization (4 lectures)
Introduction to urbanization; urban sprawl and associated environmental issues.

Unit 2: Environment in an urban setting (6 lectures)
Man as the driver of urban ecosystem; commodification of nature; metros, cities and towns as sources and sinks of resources; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).

Unit 3: Urban environmental management (8 lectures)
Benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities.

Unit 4: Environmental Pollution (2 lectures)
Definition of pollution; pollutants; classification of pollutants.

Unit 5: Air pollution (8 lectures)
Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health

(NOx, SOx, PM, CO, CO2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health.

Unit 6: Water pollution (7 lectures)
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).

Unit 7: Soil pollution (4 lectures)
Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms.

Unit 8: Noise pollution (5 lectures)
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.

Unit9: Radioactive pollution (3 lectures)
Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects).

Unit 10: Marine pollution (3 lectures)
Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management.

Unit 11: Pollution control (10 lectures)
Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi.

Practical: (Credits: Practicals-2)
EVSHGEC03P Or EVSGCOR03P

1. Estimation of soil parameters: pH & Temperature; Soil porosity, Bulk density, Organic carbon.
2. Estimation of Ground & surface water quality parameters (COD, BOD, DO, nitrate, chlorine, cadmium, mercury). Estimation of air quality parameters (NOx, SOx, SPM).
3. Field visit to effluent treatment plants (ETP)/ sewage treatment plants (STP). Total coliform load of water sample. Noise monitoring (Leq).

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.

CORE COURSE 4: BIODIVERSITY AND CONSERVATION
EVSHGEC04T Or EVSGCOR04T
(Credits: Theory-4)
Theory (60 Lectures)

Unit 1: Levels of organization in living world (8 lectures)
From genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic time scale; species concept – what's in a name?; how many species are there on earth?; concept and types of speciation.

Unit 2: Biodiversity patterns (4 lectures)
Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation.

Unit 3: Biodiversity estimation (10 lectures)
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; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.

Unit 4: Importance of biodiversity (8 lectures)
Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

Unit 5: Threats to biodiversity (10 lectures)
Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis.

Unit 6: Conservation of biodiversity (10 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), role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data Book; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources.

Unit 7: Biodiversity in India (10 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; impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan.

Practicals: (Credits: Practicals-2)
EVSHGEC04P Or EVSGCOR04P

1. Data Base: NCBI, UNIPROT, PDB
2. Sequence Collection: mRNA, Protein Sequences from NCBI and UNIPROT. Sequence alignment: Pair wise and multiple sequence alignment, using MUSCLE, CLUSTALW, Alignment representation using Weblogo.

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.

DISCIPLINE SPECIFIC ELECTIVE 1: ENERGY AND ENVIRONMENT
Credits: (Theory-5, Tutorials-1)
(EVSGDSE01T)
Theory (75Lectures)

Unit 1: Introduction (8 lectures)
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

Unit 2: Energy resources (12 lectures)
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 (12 lectures)
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.

Unit 4: Energy, environment and society (12 lectures)
Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and, urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.

Unit 5: Energy, ecology and the environment (9 lectures)
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 6: Politics of energy policy (10 lectures)
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 neighbors.

Unit 7: Our energy future (12 lectures)
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.

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.

DISCIPLINE SPECIFIC ELECTIVE 2: NATURAL HAZARDS AND DISASTER MANAGEMENT

Credits: (Theory-5, Tutorials-1)
(EVSGDSE02T)
Theory (75 Lectures)

Unit 1: Introduction (9 lectures)

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 (17 lectures)

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 (18 lectures)
Impacts of anthropogenic activities such as rapid urbanization, 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; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.

Unit 4: Risk and vulnerability assessment (7 lectures)
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.

Unit 5: Mitigation and preparedness (12 lectures)
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 (12 lectures)
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.

Suggested Readings:
1. Coppola D. P. 2007. *Introduction to International Disaster Management*. Butterworth Heinemann.
2. Cutter, S.L. 2012. *Hazards Vulnerability and Environmental Justice*. Earth Scan, Routledge Press.
3. Keller, E. A. 1996. *Introduction to Environmental Geology*. Prentice Hall, Upper Saddle River, New Jersey.
4. Pine, J.C. 2009. *Natural Hazards Analysis: Reducing the Impact of Disasters*. CRC Press, Taylor and Francis Group.

5. Schneid, T.D. & Collins, L. 2001. *Disaster Management and Preparedness*. Lewis Publishers, New York, NY.
6. Smith, K. 2001. *Environmental Hazards: Assessing Risk and Reducing Disaster*. Routledge Press.
7. Wallace, J.M. & Hobbs, P.V. 1977. *Atmospheric Science: An Introductory Survey*. Academic Press, New York.
8. Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P. & Juyal,N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. *Quaternary Science Reviews* **77**: 156–166.

DISCIPLINE SPECIFIC ELECTIVE 3: SOLID WASTE MANAGEMENT
Credits: (Theory-4)
(EVSGDSE03T)
Theory (60 Lectures)

Unit 1: Introduction (3 lectures)
Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

Unit 2: Effect of solid waste disposal on environment (8 lectures)
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 landfill leachate on soil characteristics and ground water pollution.

Unit 3: Solid waste Management (14 lectures)
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.

Unit 4: Industrial waste management (6 lectures)
Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack

emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

Unit 5: Resource Recovery (8 lectures)
4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit 6: Waste- to- energy (WTE) (4 lectures)
Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Unit 7: Integrated waste management (4 lectures)
Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

Unit 8: Life cycle assessment (LCA) (5 lectures)
Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

Unit 9: Policies for solid waste management (8 lectures)
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: (Credits: Practical-2)
(EVSGDSE03T)

1. Field Study

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.

DISCIPLINE SPECIFIC ELECTIVE 4: ORGANISMAL AND EVOLUTIONARY BIOLOGY
Credits: (Theory-5, Tutiorals-1)
(EVSGDSE04T)
Theory (75 Lectures)

Unit 1: History of life on Earth (12 lectures)
Paleontology and evolutionary History; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of plants and animals; stages in primate evolution including Homo.

Unit 2: Introduction (12 lectures)
Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.

Unit 3: Evolution of unicellular life (12 lectures)
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; anaerobic metabolism, photosynthesis and aerobic metabolism.

Unit 4: Geography of evolution (7lectures)
Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity.
Unit 5: Molecular evolution (12 lectures)
Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

Unit 6: Fundamentals of population genetics (20 lectures)

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.

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.

SKILL ENHANCEMENT COURSE 1: BIOLOGICAL TECHNIQUES (EVSSSEC01M)
2 Credits
Lectures -20

Unit1: Basic Histological and Cytological Techniques (5 lectures):
Fixation and Fixatives; Tissue-processing & Microtomy; Staining

Unit 2: Microscopy (10 lectures):
Components of microscope; magnification and illumination; Types of microscope – Light, Electron, Phase, Polarised, Fluorescence

Unit 3: Biological Analysis(5 lectures):
Collection and preservation of plankton; Enumeration of net plankton, counting in Sedgwick Rafter cell.

Suggested Reading:

1. Carson, Susan Molecular Biology Techniques (Third Edition)
2. Ghatak, K. L., Techniques and Methods in Biology
3. Ananta Swargiary, Biological Tools and Techniques (A text book for UG and PG students of Life Sciences), Kalyani Publishers, New Delhi.

SKILL ENHANCEMENT COURSE 2: ENVIRONMENTAL (EVSSSEC02M) MICROBIOLOGY
2 Credits
Lectures -20

Unit1: Bacteriology(10 lectures): Bacterial morphology: Shape, size, structure and function of bacterial cell membrane, cell wall, capsule, flagella.

Unit2: Virology(10 lectures): Descriptive properties of virus; Morphology and structure of bacteriophages

Suggested Reading:

1. Ian T. Paulsen, Andrew J. Holmes , Environmental Microbiology: Methods and Protocols, Humana Press
2. J. F. T. Spencer, Alicia L. Ragout de Spencer Environmental Microbiology: Methods and Protocols Springer Science & Business Media.
3. Pradipta K. Mahapatra Textbook of Environmental Microbiology I.K. International Publishing House Pvt. Limited
4. Alan Varnam, Malcolm Evans Environmental Microbiology, CRC Press
5. Tortora, Funke, Case, Microbiology an Introduction, Pearson Publication
6. Dubey and Maheswari; A Textbook of Microbiology, S. Chand Publication
7. Joanne Willey , Linda Sherwood , Chris Woolverton; Prescott's Microbiology