Syllabus

for

B.Sc. (Honours) in Environmental Science

2018-2019

Under
Choice Based Credit System (CBCS)

UNIVERSITY OF KALYANI

WEST BENGAL

PREAMBLE

The Undergraduate Board of Studies in Environmental Science, University of Kalyani has redesigned and revised the syllabus of B.Sc. (Honours) in Environmental Science under Semester Wise Choice Based Credit System (CBCS) scheme following the recommendations and guidelines of University Grants Commission (UGC) and the notification (No. FCUG/KU-914/17-18 dated 16.11.2017) of the University of Kalyani. After thorough and threadbare examination of the drawbacks of the existing syllabus the UG Board of studies has formulated the present curriculum inclusive of its contents, relevance, quality and pattern of teaching-learning and examination. The contents, structure and date of effect of the proposed syllabus will be decided by the appropriate authority of the University of Kalyani following its acceptance and approval.

As enshrined in the UGC's vision of introducing such new system the main objective of framing this new syllabus of B.Sc. (Honours) in Environmental Science is to impart the students a holistic understanding of the subject giving substantial weightage in both the core contents, skill and ability enhancement. The syllabus has given due importance on the main streams of the body of knowledge on "Environment" with due recognition of its wide spectrum.

The ultimate goal of the syllabus is to enable the students to have an in-depth knowledge on the subject and enhance their scope of employment at the end. Adequate emphasis has been given on the new and emerging techniques and understanding of the subject under the changing regime and global context.

In order to offer a broader window of exposure it is required for the students of Environmental Science (Hons) to select their Generic Elective (GE) Course from a basket of the following other subjects or disciplines: Chemistry/ Botany/ Zoology/ Physiology/ Microbiology/ Molecular Biology and Biotechnology/ Physics/ Geography.

A course on "dissertation" has been introduced to offer special and advanced knowledge as well as to infuse interest, orientation and promotion of skill in research among the students of Environmental Science (Hons).

Hope the proposed curriculum will make it more contextual, viable and suitable to cater the needs of students of Environmental Science.

Undergraduate Board of Studies

in

Environmental Science and Environmental Studies

CURRICULUM
UNDER
CHOICE BASED CREDIT SYSTEM (CBCS)
UNIVERSITY OF KALYANI, KALYANI

OUTLINE OF CHOICE BASED CREDIT SYSTEM

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective.

2.2. Dissertation/Project: An elective course may be designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

2.3. Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and *vice versa* and such electives may also be referred to as Generic Elective.

3. Ability Enhancement Courses (AEC): The Ability Enhancement (AE) Courses may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement; i. Environmental Science and ii. English/MIL Communication. These are mandatory for all disciplines. SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

3.1. Ability Enhancement Compulsory Courses (AECC): Environmental Science, English Communication/MIL Communication.

3.2. Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

UG SEMESTER WISE CBCS COURSE STRUCTURE FOR ENVIRONMENTAL SCIENCE HONOURS

TABLE 1. TOTAL NUMBER OF COURSES IN UG-CBCS (B. Sc. HONS) IN ENVIRONMENTAL SCIENCE

Types of Courses	Core Course (CC)	Elective Course		Ability Enhancement Course		Total
		Discipline Specific Elective (DSE)	Generic Elective (GE)	Ability Enhancement Compulsory Course (AECC)	Skill Enhancement Course (SEC)	
No. of Course	14	04	04	02	02	26
Credit/Course	06	06	06	02	02	140

TABLE 2. DETAILS OF COURSES & CREDIT OF B. Sc. (HONS) IN ENVIRONMENTAL SCIENCE UNDER CBCS

Course	Total no of Papers	Credit			
		Theory		Practical	
		Credit/ Paper	Total	Credit/ paper	Total
Core Courses (CC) (6)	14	4	14x4=56	2	14x2=28
Discipline Specific Elective (DSE) (6)	04	4	4x4=16	2	2x4=8
Generic Elective (GE (6)	04	4	4x4=16	2	2x4=8
Ability Enhancement Compulsory Course (Language) (AECC) (2)	02	2	2x2=4	-	-
Skill Enhancement (SEC) (2)	02	2	2x2=4	-	-
Total No. of Courses/ Sem	26	-	96	-	44
Total Credit			96 + 44 = 140		

TABLE 3. SEMESTER WISE DISTRIBUTION OF COURSES & CREDITS IN B. Sc. (HONS.) IN ENVIRONMENTAL SCIENCE

Courses/ Credits	**SEM-I**	**SEM-II**	**SEM-III**	**SEM-IV**	**SEM-V**	**SEM-VI**	**Total No. of Courses**	**Total Credits**
Core Courses (**CC) (6)**	**2**	**2**	**3**	**3**	**2**	**2**	**14**	**84**
Discipline Specific Elective (**DSE) (6)**	**-**	**-**	**-**	**-**	**2**	**2**	**04**	**24**
Generic Elective (**GE) (6)**	**1**	**1**	**1**	**1**	**-**	**-**	**04**	**24**
Ability Enhancement Compulsory Course (Language) (**AECC) (2)**	**1**	**1**	**-**	**-**	**-**	**-**	**02**	**04**
Skill Enhancement Course (**SEC) (2)**	**-**	**-**	**1**	**1**	**-**	**-**	**02**	**04**
Total No. of Courses/ Sem	**04**	**04**	**05**	**05**	**04**	**04**	**26**	**-**
Total Credits/Sem	**20**	**20**	**26**	**26**	**24**	**24**	**-**	**140**

TABLE 4. SEMESTER & COURSE WISE CREDIT DISTRIBUTION IN B.Sc.(HONS) IN ENVIRONMENTAL SCIENCE

(6 Credit: 75 Marks)

SEMESTER-I				
Course Code		**Course Title**	**Course Nature**	**Credit**
UG-ENVS-H-CC-01	UG-ENVS-H-CC-L -01 UG-ENVS-H-CC-P -01	Earth and Earth Surface Processes	Core	4+2=6
UG-ENVS-H-CC-02	UG-ENVS-H-CC-L -02 UG-ENVS-H-CC- P-02	Environmental Chemistry and Environmental Physics	Core	4+2=6
UG-ENVS-H-GE-01	UG-ENVS-H-GE-L -01 UG-ENVS-H-GE- P-01	Environment and Society # *	GE	4+2=6
UG-ENVS-H-AECC-01		English Communication / MIL	AECC	2
Total		**4 courses**	**Total**	**20**
SEMESTER-II				
Course Code		**Course Title**	**Course Nature**	**Credit**
UG-ENVS-H-CC-03	UG-ENVS-H-CC-L-03 UG-ENVS-H-CC-P-03	Water and Water Resources	Core	4+2=6
UG-ENVS-H-CC-04	UG-ENVS-H-CC-L-04 UG-ENVS-H-CC-P-04	Land, Soil Conservation and Management	Core	4+2=6
UG-ENVS-H-GE-02	UG-ENVS-H-GE-L-02 UG-ENVS-H-GE-P-02	Wildlife Management # *	GE	4+2=6
UG-ENVS-H-AECC-02		Environmental Studies	AECC	2
Total		**4 courses**	**Total**	**20**
SEMESTER-III				
Course Code		**Course Title**	**Course Nature**	**Credit**
UG-ENVS-H-CC-05	UG-ENVS-H-CC-L-05 UG-ENVS-H-CC-P-05	Ecology and Ecosystems	Core	4+2=6
UG-ENVS-H-CC-06	UG-ENVS-H-CC-L-06 UG-ENVS-H-CC-P-06	Biodiversity and Conservation	Core	4+2=6
UG-ENVS-H-CC-07	UG-ENVS-H-CC-L-07 UG-ENVS-H-CC-P-07	Atmosphere and Global Climate change	Core	4+2=6
UG-ENVS-H-GE-03	UG-ENVS-H-GE-L-03 UG-ENVS-H-GE-P-03	Gender and Environment # *	GE	4+2=6
UG-ENVS-H- SEC-01		1a)Remote Sensing, Geographic Information System (GIS) and Application 1b)Occupational Health and Environmental Safety (*Any one from this group*)	SEC	2
Total		**5 courses**	**Total**	**26**
SEMESTER-IV				
Course Code		**Course Title**	**Course Nature**	**Credit**
UG-ENVS-H-CC-08	UG-ENVS-H-CC-L-08 UG-ENVS-H-CC-P-08	Systematics and Biogeography	Core	4+2=6
UG-ENVS-H-CC-09	UG-ENVS-H-CC-L-09 UG-ENVS-H-CC-P-09	Natural Resources Management and Sustainability	Core	4+2=6
UG-ENVS-H-CC-10	UG-ENVS-H-CC-L-10 UG-ENVS-H-CC-P-10	Environmental Pollution and Human Health	Core	4+2=6

UG-ENVS-H-GE-04	UG-ENVS-H-GE-L-04 UG-ENVS-H-GE-P-04	Green Chemistry, Green Technology and Environmental Applications # *	GE	4+2=6
UG-ENVS-H- SEC-02		2a)Environment Impact and Risk Assessment 2b)Environmental Quality Monitoring and Assessment (*Any one from this group*)	SEC	2
Total		**5 courses**	**Total**	**26**
SEMESTER-V				
Course Code		**Course Title**	**Course Nature**	**Credit**
UG-ENVS-H-CC-11	UG-ENVS-H-CC-L-11 UG-ENVS-H-CC-P-11	Environmental Biotechnology	Core	4+2=6
UG-ENVS-H-CC-12	UG-ENVS-H-CC-L-12 UG-ENVS-H-CC-P-12	Evolutionary Biology	Core	4+2=6
UG-ENVS-H-DSE-01	UG-ENVS-H-DSE-L-01 UG-ENVS-H-DSE-P-01	1a)Energy and Environment 1b)Ecotoxicology and Environmental Health (*Any one from this group*)	DSE	4+2=6
UG-ENVS-H-DSE-02	UG-ENVS-H-DSE-L-02 UG-ENVS-H-DSE-P-02	2a)Environmental Economics 2b)Waste and Wastewater Management (*Any one from this group*)	DSE	4+2=6
Total		**4 courses**	**Total**	**24**
SEMESTER-VI				
Course Code		**Course Title**	**Course Nature**	**Credit**
UG-ENVS-H-CC-13	UG-ENVS-H-CC-L-13 UG-ENVS-H-CC-P-13	Environmental Legislation and Policy	Core	4+2=6
UG-ENVS-H-CC-14	UG-ENVS-H-CC-L-14 UG-ENVS-H-CC-P-14	Urban Ecosystems	Core	4+2=6
UG-ENVS-H-DSE-03	UG-ENVS-H-DSE-L-03 UG-ENVS-H-DSE-P-03	3a)Natural Hazards and Disaster Management 3b)Instrumental Techniques for Environmental Analysis (*Any one from this group*)	DSE	4+2=6
UG-ENVS-H-DSE-04	UG-ENVS-H-DSE-D-04 UG-ENVS-H-DSE-P-04	Dissertation	DSE	4+2=6
Total		**4 courses**	**Total**	**24**
Total (All semesters)		***26 courses***	***Total***	***140***

B.Sc. (Honours) with Environmental Science students may select their Generic Elective courses (GE), any two from Chemistry/ Botany/ Zoology/ Physiology/ Microbiology/Molecular biology & Biotechnology/ Physics/ Geography and any branch of Life Sciences .

***** Generic Elective courses (GE) may be opted by the students of other honours subjects.

CORE COURSE 01 (Code: UG-ENVS-H-CC-01)

EARTH AND EARTH SURFACE PROCESSES

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -01 **CREDITS: 4; Lectures-60**

Unit 1: History of Earth

Formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of earth; geological time scale and major changes on the earth's surface; holocene and the emergence of humans, role of humans in shaping landscapes; development of cultural landscapes.

Unit 2: Earth system processes

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hot spots, plate boundaries; sea floor spread; earthquakes; volcanic activities; orogeny; continental drift, Pangaea and present-day continents, paleontological evidences of plate tectonics; continental collision and mountain formation with specific example of the Himalaya.

Unit 3: Minerals and rocks

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

Unit 4: Earth surface processes

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

Unit 5: Importance of being a mountain

Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; development of glaciers, perennial river systems and evolution of monsoon in Indian subcontinent; formation of Indo-Gangetic Plains.

UG-ENVS-H-CC-P -01 **CREDITS: 2**

Practical:

- Hand specimen: rocks and minerals.
- Microscopic studies of thin section of rock and minerals.
- Topographical sheet interpretation.

Suggested Readings

1. Bridge, J., & Demicco, R. 2008. *Earth Surface Processes, Landforms and Sediment deposits*. Cambridge University Press.
2. Duff, P. M. D., & Duff, D. (Eds.). 1993. *Holmes' Principles of Physical Geology*. Taylor & Francis.
3. Gupta, A. K., Anderson, D. M., & Overpeck, J. T. 2003. Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. *Nature* **421:** 354-357.
4. Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. *Current Science* **90:** 1082-1090.
5. Keller, E. A. 2011. *Introduction to Environmental Geology* (5^{th} edition). Pearson Prentice Hall.
6. Krishnan, M. S. 1982. *Geology of India and Burma*. CBS Publishers & Distributors.
7. Leeder, M., Arlucea, M. P. 2005. *Physical Processes in Earth and Environmental Sciences.* Blackwell Publishing.
8. Pelletier, J. D. 2008. *Quantitative Modeling of Earth Surface Processes* (Vol. 304). Cambridge: Cambridge University Press. Chicago.

CORE COURSE 02: (Code: UG-ENVS-H-CC-02)

Environmental Chemistry and Environmental Physics

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -02 **CREDITS: 4; Lectures-60**

Unit 1: Fundamentals of environmental chemistry

Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds), mole concept, molarity and normality, quantitative volumetric analysis.

Thermodynamic system; types of chemical & reactions products; solutes and solvents; redox reactions, concepts of pH equation, electrochemical cells.

Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, xenobiotic compounds like pesticides and dyes, synthetic polymers.

Unit 2: Atmospheric chemistry

Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, case studies; reactions of NO_2 and SO_2; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit 3: Water chemistry

Chemical and physical properties of water; water quality parameters (physical, chemical & biological), heavy metal in water, solubility of metals, complex formation and chelation; colloidal particles; water quality monitoring.

Unit 4: Soil chemistry

Soil composition; relation between organic carbon and organic matter, 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; soil quality monitoring.

Unit 5: Fundamentals of environmental physics

Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency), black body radiation, Kirchhoff's law, Boltzmann equation, spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law, photovoltaic and solar cells; scattering of light, Rayleigh and Mia scattering.

Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Cariolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power, efficiency of turbines, wind mills and hydroelectric power plants.

Unit 6: Movement of pollutants in environment

Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence.

UG-ENVS-H-CC-P -02 **CREDITS: 2**

Practical:

- Preparation of primary and secondary standard solutions.
- Estimation of metals using standard potassium dichromate/ potassium permanganate solution.
- Measurement of physicochemical parameters of soil and water samples (pH, conductivity, hardness, alkalinity), soil organic matter.
- Field visit to renewable/ non-renewable energy plants.

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. Manahan, S. E. 2000. *Fundamentals of Environmental Chemistry*. CRC Press.
9. Pani, B. 2007. *Textbook of Environmental Chemistry*. IK international Publishing House.

GENERIC ELECTIVE 01 (Code: UG-ENVS-H-GE-01)

ENVIRONMENT AND SOCIETY

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

Preamble: The course examines the relationship between the environment and society enabling the students to understand and appreciate the role played by environment, society, and, their interface in shaping environmental decisions. The students will be enabled to think critically on environmental issues.

UG-ENVS-H-GE-L-01 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Social and cultural construction of 'environment'; environmental thought from historical and contemporary perspective in light of the concepts of Gross Net Happiness and Aldo Leopold's Land Ethic.

Unit 2: Issues in environmentalism

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 water management in a global context; interface between environment and society.

Unit 3: Development-environment conflict

Developmental issues and related impacts such as ecological degradation; environmental pollution; development-induced displacement, resettlement, and rehabilitation: problems, concerns, and compensative mechanisms; discussion on Project Affected People (PAPs).

Unit 4: Urbanization and environment

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

Unit 5: Environment and social inequalities

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

Unit 6: Regulatory framework

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

Unit 7: Community participation

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

UG-ENVS-H-GE-P -01 **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation:

- Interactive session with community for awareness development and survey documentation (Socio-economic/socio cultural/ and other environmental perspectives).

Suggested Readings

1. Chokkan, K. B., Pandya, H. & Raghunathan, H. (eds). 2004. *Understanding Environment*. Sagar Publication India Pvt. Ltd., New Delhi.
2. Robbins, P, J Hintz & SA Moore. 2014. Environment and Society. Wiley Blackwell.
3. Elliot, D. 2003. *Energy, Society and Environment, Technology for a Sustainable Future*. Routledge Press.
4. Guha, R. 1989. *Ecological change and peasant resistance in the Himalaya*. Unquiet Woods, Oxford University Press, Delhi.
5. Leopold, A. 1949. *The Land Ethic*. pp. 201-214. Chicago, USA.
6. National Research Council (NRC). 1996. *Linking Science and Technology to Society's Environmental Goals*. National Academy Press.
7. 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.

CORE COURSE 03 (Code: UG-ENVS-H-CC-03)

WATER AND WATER RESOURCES

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -03 **CREDITS: 4; Lectures-60**

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).

Unit 2: Properties of water

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

Unit 3: Surface and subsurface water

Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of water; formation and properties of aquifers; techniques for ground water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands and their management

Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India.

Unit 5: Marine resource management

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

Unit 6: Water resource 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; role of state in water resource management.

Unit 7: Water resource conflicts

Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi-purpose river valley projects in India and their environmental and social impacts; case studies of dams.

- Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.

Unit 8: Major laws and treaties

National water policy; water pollution (control and prevention) Act 1972; Indus water treaty; Ganges water treaty; Teesta water treaty; National River linking plan: ecological and economic impacts.

UG-ENVS-H-CC-P -03 **CREDITS: 2**

Practical:

- Field study related to rainwater harvesting / groundwater wells and document preparation.
- Field visit to wetland and document preparation.
- Water demand in domestic/ agricultural fields/ industrial areas through preparation of survey sheets followed by documentation.

Suggested Readings

1. Bansil, P. C. 2004. *Water Management in India*. Concept Publishing Company, India.
2. Brebbia, C. A. 2013. *Water Resources Management VII*. WIT Press.
3. CEA. 2011. *Water Resources and Power Maps of India*. Central Board of Irrigation & Power.
4. Grumbine, R. E. & Pandit, M. K. 2013. Threats from India's Himalaya dams. *Science* 339: 36-37.
5. Loucks, D. P., Stedinger, J. R. & Haith, D. A. 1981. *Water Resource Systems Planning and Analysis*. Englewood Cliffs, NJ, Prentice Hall.
6. Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-Hill Publications.
7. Schward & Zhang, 2003. *Fundamentals of Groundwater*. John Willey and Sons.
8. Souvorov, A. V. 1999. *Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management*. Elsevier Publications.
9. Vickers, A. 2001. *Handbook of Water Use and Conservation*. Water Plow Press.

CORE COURSE 4 (Code: UG-ENVS-H-CC-04)

LAND AND SOIL CONSERVATION AND MANAGEMENT

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -04 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Land as a resource, soil health; ecological and economic importance of soil; types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility.

Unit 2: Fundamentals of soil science

Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity.

Unit 3: Soil degradation - causes

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

Unit 4: Landuse changes and land degradation

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

Unit 5: Costs of land degradation

Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.

Unit 6: Controlling land degradation

Sustainable land use planning; role of databases and data analysis in land use planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

UG-ENVS-H-CC-P -04 **CREDITS: 2**

Practical:

- Determination of soil organic matter, nutrients (N, P, K), Soil water holding capacity, Soil texture analysis.
- Soil profile study.
- Identification of degraded land using remote sensing data and topographical sheets.

Suggested Readings

1. Brady, N. C. & Well, R. R. 2007.*The Nature and Properties of Soils* (13th edition), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. *Ambio* 22: 167-172.
3. Johnson, D. L. 2006. *Land Degradation* (2nd edition). Rowman & Littlefield Publishers.
4. Marsh, W. M. & Dozier, J. 1983. *Landscape Planning: Environmental Applications*. John Wiley and Sons.
5. Oldeman, L. R. 1994. The global extent of soil degradation. *Soil resilience and sustainable land use, 9*. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
6. Pandit, M. K. et. al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. *Biodiversity Conservation* 16: 153-163.
7. Pandit, M. K. & Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N. S., Gibson, L. & Raven, P. H. *Conservation Biology: Voices From the Tropics.* pp. 123-133. Wiley-Blackwell, Oxford, U*K.*

   *(file:///Users/mkpandit/Do*wnloads/Raven%20et%20al.%202013.%20CB%20Voices%20from%20Tropics%20(2).pdf).
8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. *Conservation Biology* 17: 358-366.
9. Scherr, S. J. 1999. *Soil degradation: A threat to developing-country food security by 2020?* (Vol. 27). International Food Policy Research Institute.

GENERIC ELECTIVE 02 (Code: UG-ENVS-H-GE-02)

WILDLIFE MANAGEMENT

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-GE-L -02 **CREDITS: 4; Lectures-60**

Unit 1: Introduction to wildlife management

Wildlife: Concept and values; wildlife conservation and management; philosophy of wildlife management; why is it necessary to worry about human-wildlife conflicts? What is the role of government, wildlife biologists and social scientists, concept of deep and shallow ecology.

Unit 2: Evolution of the concept of wildlife management

Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetka wall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; Bishnoi community; understanding wildlife management, conservation and policies regarding protected areas in 21st century.

Unit 3: Wildlife conservation laws in India

Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, brief introduction to Wildlife Protection Act of 1972, Forest Act 1927, Environmental Protection Act 1986, and Forest conservation Act 1920; introduction of Tiger task force, Status of current protected areas in India.

Unit 4: Socio-economic and legal basis of conflicts

Concepts of development and encroachment, who is the intruders: human or animal? Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: luxury hotels within protected areas vs. displacement of native tribes, forest produce as a need vs. forest exploitation, introduction to tribal rights in India, demographic profile of tribes in India, importance of forest produce to tribal populations, Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

Unit 5: Wildlife conflicts

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.

Unit 6: 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; Community participation; Conservation-Development linkages; 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.

UG-ENVS-H-GE-P -02 **CREDITS: 2**

Practical:

- Orientation to field biology and natural history. Observations and collection of study material, wildlife signs and evidences.
- Study and identification of fish and insects commonly used in any study area.
- Visit to wildlife sanctuary/National Park/Biosphere reserve to make an appraisal of the habitat, wildlife profile and threats.
- Visit to Zoo and Museum followed by document preparation.

Suggested Readings

1. Conover, M. 2001. *Resolving Human Wildlife Conflicts*, CRC Press.
2. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation* 13: 458-466.
3. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. *International Biodeterioration & Biodegradation* 45: 97-102.
4. Paty, C. 2007. *Forest Government and Tribe*. Concept Publishing Company.
5. Treves, A. & Karanth, K. U. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17: 1491-1499.
6. Woodroffe, R. 2005. *People and Wildlife: Conflict and Coexistence*. Cambridge.
7. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. *People and Wildlife, Conflict or Co-existence?* (No. 9). Cambridge University Press.

CORE COURSE 5 (Code: UG-ENVS-H-CC-05)

ECOLOGY AND ECOSYSTEMS

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -05 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

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

Ecological amplitude; Limiting factors; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals.

Unit 3: 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 4: Ecology of communities

Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, proto cooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: types, processes and models.

Unit 5: Ecosystem ecology

Ecosystem structure and functions; abiotic and biotic components of ecosystem; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids; ecosystem services; Some model ecosystems: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands.

Unit 6: Biogeochemical cycles and nutrient cycling

Concepts of pools, flux, turnover time; types of biogeochemical cycles; carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; nutrient budget; impact of anthropogenic activities on the nutrient cycles; nutrient conservation strategies.

Unit 7: Biological invasions

Concept of exotics and invasive; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; economic costs of biological invasions.

UG-ENVS-H-CC-P -05 **CREDITS: 2**

Practical:

- Qualitative and quantitative analysis of planktons of aquatic systems.
- Determination of species, dominance and frequency using quadrate/ plot method.
- Determination of dissolved oxygen, free carbon dioxide and primary productivity of water samples collected from aquatic ecosystems.
- Ecological field visit: pond/forest/river/wetland or other ecosystem.

Suggested Readings

1. Odum, E. P. & Barrett, G. W. 2006. Fundamentals of Ecology (Cengage).
2. Molles, M. C. Ecology. 2009, McGraw Hill.
3. Beeby, A. Applied Ecology. Chapman and Hall.
4. Begon, M. Harper, J. L & Townsend, C. R. 2006. Ecology (Blackwell).
5. Smith R. L & Smith, T. M. Ecology and Field Biology. Benjamin Cummings/Addition Wesley.
6. Loreau, M. & Inchausti, P. 2002. *Biodiversity and Ecosystem functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.
7. Dash, M. C. & S. P. Dash, Fundamental of Ecology. Tata Mcgraw Hill Publication.
8. Pimentel, D. (Ed.). 2011. *Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species*. CRC Press.
9. Singh, J. S., Singh, S. P. & Gupta, S. R. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications.
10. Santra, S. C. 2010. Fundamentals of Ecology and Environmental Biology, New Central Book Agency.

CORE COURSE 06 (Code: UG-ENVS-H-CC-06)

BIODIVERSITY AND CONSERVATION

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -06 **CREDITS: 4; Lectures-60**

Unit 1: Levels of organization in living world

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

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

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

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

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: Biodiversity Conservation

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

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. Biological diversity Act & rule (2002/ 2004) implementation status.

UG-ENVS-H-CC-P -06 **CREDITS: 2**

Practical:

Biodiversity measurement techniques: Biodiversity richness and diversity indexes.

- IUCN red list categorisation- Guideline criteria.
- Ecorestoration – site visit.

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. Jeffries, M. J. 2006. Biodiversity and Conservation. Routledge.
4. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. *The Botanical Review* 53: 80-192.
5. Singh, J. S., Singh, S. P. & Gupta, S. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.
6. Sodhi, N. S. & Ehrlich, P. R. (Eds). 2010. *Conservation Biology for All*. Oxford University Press.
7. Sodhi, N. S., Gibson, L. & Raven, P. H. 2013. *Conservation Biology: Voices from the Tropics.* Wiley-Blackwell, Oxford, UK.
8. Maity, P. K. and Maity, P. 2011. Biodiversity –Perception, Peril & Preservation. PHI.

CORE COURSE 07 (Code: UG-ENVS-H-CC-07)

ATMOSPHERE AND GLOBAL CLIMATE CHANGE

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -07 **CREDITS: 4; Lectures-60**

Unit 1: Fundamentals of atmospheric chemistry

Atmospheric structure and composition, Milankovitch cycles. 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. Green house gases (GHGs); greenhouse effect; global warming.

Unit 2: Meteorology and atmospheric stability

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; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; *El Nino* and *La Nina*; tropical cyclone; Indian monsoon and its development, changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; effect of urbanization on micro climate; Asian brown clouds.

Unit 3: Global warming and climate change

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO_2 fertilization and agriculture; impact on economy and spread of human diseases.

Unit 4: Ozone layer depletion

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

Unit 5: Climate change and policy

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

UG-ENVS-H-CC-P -07 **CREDITS: 2**

Practical:

- Preparation of meteorological charts, graphs and windrose,
- Handling of meteorological data recording instruments (Rain gauge, Anemometer, wet bulb dry bulb thermometer, Barometer) and their uses.
- Field visit to meteorological centre.

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 Commentaries with 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. *Climate Change and India*. Universities Press, India.
9. Philander, S. G. 2012. *Encyclopedia of Global Warming and Climate Cha*nge (2nd edition). Sage Publications.

SKILL ENHANCEMENT COURSE 01 (Code: UG-ENVS-H- SEC-01a)

REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM & MODELLING

FULL MARKS: 50, CREDITS: 2

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

Unit 1: Remote Sensing: definitions and principles; electromagnetic (EME) spectrum; interaction of EMR with Earth's surface; spectral signature; satellites and sensors; aerial photography and image interpretation.

Unit 2: Geographical Information Systems: definitions and components; spatial and non-spatial data; raster and vector data; database generation; database management system; land use/ land cover mapping; overview of GIS software packages; GPS survey, data import, processing, and mapping.

Unit 3: Applications and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies.

Unit 4: Basic elements of statistical analyses: sampling; types of distribution – normal, binomial, poisson; measurements of central tendency and dispersion; skewness; kurtosis; hypothesis testing; parametric and non-parametric tests; correlation and regression; curve fitting; analysis of variance.

Unit 5: Demonstrative exercise

- Visual interpretation of standard False Colour Composite (FCC) data.
- Thematic map generation.
- Digitisation of thematic layer.
- Overlay analysis of thematic layer in GIS environment.
- GIS laboratory visit.

Suggested Readings

1. Zar, J. H. 2010. *Biostatistical Analysis* (5^{th} edition). Prentice Hall Publications.
2. Edmondson, A. & Druce, D.1996. *Advanced Biology Statistics*. Oxford University Press.
3. Demers, M. N. 2005. *Fundamentals of Geographic Information System*. Wiley & Sons.
4. Richards, J. A. & Jia, X. 1999. *Remote Sensing and Digital Image Processing*. Springer.
5. Sabins, F. F. 1996. *Remote Sensing: Principles an Interpretation*. W. H. Freeman.

-OR-

SKILL ENHANCEMENT COURSE 01: (Code: UG-ENVS-H- SEC- 01b)

OCCUPATIONAL HEALTH AND ENVIRONMENTAL SAFETY

FULL MARKS: 50, CREDITS: 2

Preamble: This course introduces the students to acquire knowledge about various occupational diseases and safety measures with particular attention to accident prevention in work place, safety education and training.

Unit 1: Introduction

Concept of occupational health and diseases: Occupation related diseases, mode, effects, risk, diagnosis and methods of prevention.

Unit 2: Occupational health hazards and devices

Evaluation of injuries: Medical services in industrial establishment, its function, action programs for work related diseases at the national level.

Personal Protective Equipment: Introduction, requirements and assessment of PPE, types of PPE.

Non-respiratory personal protective devices; head, ear, face and eye protection, feet and body protection, supply, use, care and maintenance of PPE, requirements under factory Acts and Rules. Respiratory PPE: Types of respiratory PPE, supply, use, care and maintenance of breathing apparatus, training for the use of breathing apparatus.

Unit 3: Introduction to Environmental Safety

Environmental Safety: Safety awareness, annual toll of industrial accidents in India, need for safety, legal, humanitarian factors impending safety, safety audit.

Health concern for workers of textile, dye, bidi making and brick kiln factory/industry.

Unit 4: Principles of accident prevention

Definition of accidents: injury, types of accidents, causes and remedial measures, injury records, prevention, modes of prevention, physiological factors.

Unit 5: Safety education and training

Assessment of training needs, design and developments of training program.

Unit 6: Demonstrative exercise

- Industry/factory visit to assess the safety measures adopted for the workers in textile, dye, bidi making and brick kiln factory/industry and fire.
- Occupational health study of small scale industry workers through survey and documentation.

Suggested Readings

1. Reese, C. D., 2015. *Occupational health and safety management: a practical approach*. CRC press.
2. Friis, R. H., 2015. *Occupational health and safety for the 21st century*. Jones & Bartlett Publishers.

3. Erickson, P. A., 1996. *Practical guide to occupational health and safety*. Elsevier. Greenberg, M. I., 2003. *Occupational, industrial, and environmental toxicology*. Elsevier Health Sciences.
4. Greenberg, M. I. *Occupational industrial and environmental toxicology*.

GENERIC ELECTIVE 03 (Code: UG-ENVS-H-GE -03)

GENDER AND ENVIRONMENT

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-GE-L -03 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

The socially constructed 'gender' concept.

Unit 2: Gender and society

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 3: 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. 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. Instruments for change: education, media, action groups, policy and management; equity in resource availability and consumption for a sustainable future.

UG-ENVS-H-GE-P -03 **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Assignment on gender/environment: gender equity issues in rural and urban society.
- Field visit and evaluation of gendered responses to environmental degradation.

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 and Temporal Shifts in Rural India: 1971-1991. *World Development* 25: 1-42.

3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. *World Development* 29: 1623-1648.
4. Jackson, C. 1993. Doing what comes naturally? Women and environment in development *World Development* 21:1947-63.
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 rose and 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, and Activism*. Rutgers University Press.
9. Steingraber, S. 1998. *Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment.* New York: Vintage Books.
10. Zwarteveen, M. Z. 1995. *Linking women to the main canal: Gender and irrigation management*. Gatekeeper Series 54, IIED.

CORE COURSE 08 (Code: UG-ENVS-H-CC-08)

BIO-SYSTEMATICS AND BIOGEOGRAPHY

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -08 **CREDITS: 4; Lectures-60**

Unit 1: Biosystematics - Concept and approaches

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

Unit 2: Taxonomic hierarchy

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

Unit 3: Nomenclature and systems of classification

Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification.

Unit 4: Numerical and molecular systematics

Characters; variations; operational taxonomic units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted, unrooted, ultrametric trees).

Unit 5: Biogeography- An overview

Earth's history; paleo-records of diversity and diversification; continental drift and plate tectonics and their role in biogeographic patterns – past and present; biogeographical dynamics of climate change and Ice Age. Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species. Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

Unit 6: Conservation Biogeography

Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

UG-ENVS-H-CC-P -08 **CREDITS: 2**

Practical:

- Demonstration of typification procedure.
- Field visit for floral and faunal assessment of an area.
- Criteria used for designation of a protected area- preparation of worksheet.
- Study of invasive species distribution and documentation.

Suggested Readings

1. Lomolino, M. V., Riddle, B. R., Whittaker, R. J. & Brown, J. H. 2010. *Biogeography* (4^{th} 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* (3^{rd} 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.

CORE COURSE 09 (Code: UG-ENVS-H-CC-09)

NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -09 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.

Unit 2: Natural resources and conservation

Water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution. Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry. Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

Unit 3: Energy resources-Non-renewable & Renewable

Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges.

Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Unit 4: Resource management

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

UG-ENVS-H-CC-P -09 **CREDITS: 2**

Practical:

- Forest area mapping techniques.
- Water bodies mapping techniques.
- Water audit of college/ industry.
- Energy audit of college/ industry.
- Environmental audit of college.
- Visit to mine area, forest area and aquaculture farm.

Suggested Readings

1. Ginley, D. S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*. Cambridge University Press.
2. Klee, G. A. 1991. *Conservation of Natural Resources*. Prentice Hall Publication.
3. Miller, T. G. 2012. *Environmental Science*. Wadsworth Publishing Co.
4. Owen, O. S, Chiras, D. D, & Reganold, J. P. 1998. *Natural Resource Conservation – Management for Sustainable Future* (7^{th}edition). Prentice Hall.
5. Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.

CORE COURSE 10 (Code: UG-ENVS-H-CC-10)

ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -10 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Definition of pollution; pollutants; classification of pollutants.

Unit 2: Air pollution

Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NO_x, SO_x, PM, CO, CO_2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources, effects on human health and remedial strategies. Vehicular pollution and control measures.

Unit 3: Water pollution

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; water quality monitoring, COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).

Unit 4: Soil pollution

Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

Unit 5: 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; control measures.

Unit 6: Radioactive and thermal pollution

Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.

Unit 7: Marine pollution

Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones).

Unit 8: Chemistry of environmental pollutants

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

Unit 9: Pollution control

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

UG-ENVS-H-CC-P -10 **CREDITS: 2**

Practical:

- Estimation of Ground & surface water quality parameters (COD, BOD, DO, nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides).
- Estimation of air quality parameters (NO_x, SO_x, SPM).
- Field visit to effluent treatment plants (ETP)/ sewage treatment plants (STP).
- Total coliform load of water sample.
- Noise monitoring (Leq).

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 02 (Code: UG-ENVS-H-SEC-02a)

ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

FULL MARKS: 50, CREDITS: 2

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

Unit 1: Environmental impact assessment (EIA): definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA; 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: Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO 14000; sustainable development.

Unit 3: EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects, Environmental audit.

Unit 4: Life cycle assessment (LCA)- concept; 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 5: Risk assessment: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

Unit 6: Demonstrative exercise

- Model EIA preparation- Demonstrative exercise.
- Steps in environmental clearance exercise.
- Model public consultation procedure of a developmental project.

Suggested Readings

1. Barrow, C. J. 2000. *Social Impact Assessment: An Introduction.* Oxford University Press.
2. Glasson, J., Therivel, R., Chadwick, A. 1994. *Introduction to Environmental Impact Assessment*. London, Research Press, UK.
3. Judith, P. 1999. *Handbook of Environmental Impact Assessment*. Blackwell Science.
4. Marriott, B. 1997. *Environmental Impact Assessment: A Practical Guide*. McGraw-Hill, New York, USA.

-OR-

SKILL ENHANCEMENT COURSE 02 (Code: UG-ENVS-H- SEC -02b)

ENVIRONMENTAL QUALITY MONITORING AND ASSESSMENT

FULL MARKS: 50, CREDITS: 02

Preamble: This paper deals with environmental quality monitoring and assessment. An attempt will be made to have a compressive idea about different aspects of environmental contamination, with special emphasis on air, water, soil and noise qualities, perturbation of which may have adverse effects on environmental and human health. It will lay emphasis on understanding mechanisms of pollutants impact on human health by developing an understanding of different types of pollutants, their sources and mitigation measures. The students will also be introduced to the concept of standards and permissible limits.

Unit 1: Concept of environmental quality monitoring viz. physical, chemical and biological methods.

Unit 2: Assessment of water and soil quality parameters, their characterization and control strategies. Water resources-origin of waste water, types of water pollution and their effects, water quality standards (surface and drinking water), basic processes of water and waste water treatment, recovery of material from process effluents, solid and hazardous waste management-sources and classification, public health aspects, methods of collection, disposal methods.

Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

Unit 3: Concept of biomonitoring, bioindicator organisms**,** biomonitoring of water and soil quality-indicator organism (planktons, worms, molluscs/ soil microbes), biomonitoring of air quality (lichens and higher plants).

Unit 4: Assessment of air and noise quality parameters and their characterization, control strategies.

Sources and effects, behaviour and fate of air pollutions, photochemical smog, collection of gaseous and particulate air pollutants, analysis of air pollutants, SOx, NOx, CO, oxidants, ozone, hydrocarbons and particulate matter, air quality index, control of particulate and gaseous emission, ambient air quality standards, auto emission standard and noise quality standards.

Unit 5: Mapping of environmental quality zones, air and water pollution laws and standards, ISO14000.

Unit 6: Demonstrative exercise

- Determination of SPM, NOx and SOx from air samples.
- Bio-monitoring of water and soil quality (planktons, soil microbes).
- Determination of chloride, iron, arsenic, nitrate.
- Field survey based on environmental quality zone map preparation of a model area (urban/ rural/ industrial).

Suggested readings:

1. Girard, J. 2013. *Principles of Environmental Chemistry* (3rd edition). Jones & Bartlett.
2. Harnung, S. E. & Johnson, M.S. 2012. *Chemistry and the Environment*. Cambridge University Press.
3. Hites, R. A. 2012. *Elements of Environmental Chemistry* (2nd edition). Wiley & Sons.
4. Manahan, S. E. 2000. *Fundamentals of Environmental Chemistry*. CRC Press.
5. Brady, N.C. and Weil, R.R., 2002. The nature and properties of soils, 13th. *Pearson education (Singapore) Pte. Ltd. Indian Branch, 482*, pp.621-624.
6. Stevenson, F.J. and Cole, M.A., 1999. *Cycles of soils: carbon, nitrogen, phosphorus, sulfur, micronutrients*. John Wiley & Sons.
7. Santra, S. C, Environmental Science.
8. Khopkar, S. M, Environmental Pollution Analysis.
9. G. Brun Wiersma, Environmental Monitoring (CRC press).
10. Burden, F.R., Donnert, D., Godish, T. and McKelvie, ID Editors Environmental Monitoring Handbook. (McGro Hill)
11. E. Layer, Environmental Monitoring.

GENERIC ELECTIVE 04 (Code: UG-ENVS-H-GE-04)

GREEN CHEMISTRY, GREEN TECHNOLOGY AND APPLICATIONS

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-GE-L -04 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Definition and concepts: green technology, green energy, green infrastructure, green economy, and, green chemistry; sustainable consumption of resources; individual and community level participation such as small-scale composting pits for biodegradable waste, energy conservation; encouraged use of public transport instead of private transport.

Unit 2: Green technologies

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

Unit 3: Green infrastructure, planning and economy

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

Unit 4: Applications of green technologies

Increase in energy efficiency: cogeneration, motor system optimization, oxy-fuel firing, isothermal melting process, energy efficient fume hoods, compact fluorescent lights (CFLs), motion detection lighting, or programmable thermostats). Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, promotion and/or subsidy of alternative forms of transportation for employees, such as carpools, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse).

Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NO_X, Fluidized Bed Combustion, Dioxins reduction and removal methods, Thermal

Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals, solvent recovery systems, Low Volatile Organic Compound (VOC) paints and sealers).

Unit 5: **Green chemistry**

Introduction to green chemistry; principles and recognition of green criteria in chemistry; bio-degradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags.

Unit 6: Green future

Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies; green practices to conserve natural resources (organic agriculture, agroforestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly technologies.

UG-ENVS-H-GE-P-04 **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Worksheet preparation of schemes of different green processes and practices based on industry visit.
- Visit to biofertilizer, vermicomposting units, organic agriculture farms and report preparation.

Suggested Readings

1. Anastas, P. T. & Warner, J. C. 1998. *Green Chemistry: Theory & Practice*. Oxford University Press.
2. Arceivala, S. L. 2014. *Green Technologies: For a Better Future*. Mc-Graw Hill Publications.
3. Baker, S. 2006. *Sustainable Development*. Routledge Press.
4. Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. *Green technologies for a more sustainable agriculture* (No. 33721). United States Department of Agriculture, Economic Research Service.
5. Thangavel, P. & Sridevi, G. 2015. *Environmental Sustainability: Role of Green Technologies*. Springer Publications.
6. Woolley, T. & Kimmins, S. 2002. *Green Building Handbook* (Volume 1 and 2). Spon Press.

CORE COURSE 11 (Code: UG-ENVS-H-CC-11)

ENVIRONMENTAL BIOTECHNOLOGY

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -11 **CREDITS: 4; Lectures-60**

Unit 1: The structure and function of DNA, RNA and protein

Genetic materials of prokaryotes, viruses, eukaryotes and organelles; mobile DNA; chromosomal organization; Central dogma of biology.

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; post- translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes).

Unit 2: Recombinant DNA technology

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

Unit 3: Bioremediation and ecological restoration

Bioremediation: Concept, types, factors, applications, advantages and constraints; Specific bioremediation technologies (prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation. Phytoremediation – types, mechanism, case studies); Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; constructed wetlands; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in environment: hydrocarbons, substituted hydrocarbons, pesticides, heavy metals degradative pathways.

Unit 4: Ecologically safe products and processes

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

UG-ENVS-H-CC-P -11 **CREDITS: 2**

Practical:

- Isolation and characterisation of soil bacteria.
- Gram staining of bacterial sample.
- Enumeration of heterotrophic bacteria from water and soil samples (Spread plate/pore plate technique).
- Determination of chlorophylls, enzymes (catalase, peroxidase and ascorbic acid of plant samples).
- Bioassay of toxic compounds by enzyme assay or seed germination test.
- Estimation of carbohydrate, protein and DNA.
- Study of mitotic and meotic stages (*A. cepa* and grasshopper testis or pollen).

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 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.

CORECOURSE 12 (Code: UG-ENVS-H-CC-12)

EVOLUTIONARY BIOLOGY

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -12 **CREDITS: 4; Lectures-60**

Unit 1: History of life on Earth

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

Unit 2: Introduction

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

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

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

Unit 5: Molecular evolution

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

Unit 6: Fundamentals of population genetics

Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms;

speciation (allopatric, sympatric, peripatric and parapatric); convergent evolution; sexual selection; co-evolution; Hardy-Weinberg Law.

UG-ENVS-H-CC-P -12 **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation:

- Hardy-Weinberg Law and its applications.
- Determination of change in allelic frequency due to natural selection, mutation and genetic drift based on data provided from suggested readings (Sl. 10 & 11).

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.
10. Stansfield W. D. Schaums Outline of Theory and Problems of Genetics. Mcgraw-Hill Book Company ; New York.
11. Banerjee, P. K. Problems on Genetics, Molecular Genetics and Evolutionary Genetics. New Central Book Agency, Kolkata.

DISCIPLINE SPECIFIC ELECTIVE 01 (Code: UG-ENVS-H-DSE -01a)

ENERGY AND ENVIRONMENT

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-DSE-L -01a **CREDITS: 4; Lectures-60**

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

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.

Unit 4: Energy, environment and society

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

Unit 5: 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 6: 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.

Unit 7: Our energy future

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.

UG-ENVS-H-DSE-P -01a **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Prepare worksheet of energy conservation based on site visit (school/office/hospital/ municipality etc.).
- Checklist for energy saving measures.
- Visit to renewable/non-renewable energy units.

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* (2^{nd}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.

-OR-

DISCIPLINE SPECIFIC ELECTIVE 01 (Code: UG-ENVS-H-DSE- 01b)

ECOTOXICOLOGY AND ENVIRONMENTAL HEALTH

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06.

Preamble: This chapter deals with basic concepts of toxicology, categories of toxicants, their sources, action and effects. It will also consider the preventive and curative measures to reverse toxic impact and maintenance of environmental health.

UG-ENVS-H-DSE-L -01b **CREDITS: 4; Lectures-60**

Unit 1: Introduction to Environmental toxicology

Concepts of toxicants and xenobiotics: dose response relationship; EC_{50}, LC_{50} and LD_{50}: bioaccumulation and biomonitoring of chemical and biological factors influencing toxicity; types of toxicants and their effects in living systems.

Unit 2: Toxicity of heavy metals:

Sources, distribution; toxic effects of heavy metal (Lead, cadmium, chromium, mercury, arsenic, selenium); antidotal measures, case studies.

Unit 3: Pesticide toxicity

Pesticide classification, nature, exposure routes, modes of action, biological health effect; concept of pesticide resistance.

Unit 4: Emerging contaminants

Concept, types and modes of action, environmental threats and health hazards, environmental disruptors and environmental carcinogens: categories, actions and toxic effects.

Unit 5: Environmental epidemiology

Sources and impact on human life, present pollution and impact status in West Bengal; remedial measures; epidemiological studies with respect to arsenicosis, fluorosis, vector borne diseases.

Unit 6: Environmental Health

Basic concepts, physiological responses of human to relevant stress; industrial toxicology and occupational health hazards and toxic manifestations.

UG-ENVS-H-DSE-P-01b **CREDITS: 2**

Practical:

- Toxicity bioassay through germination (LD_{50}).
- Toxicity bioassay through microbial test.
- Epidemiological survey in arsenic affected areas.

Suggested Readings:

1. Klassen, C. 2017. Cassarett & Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill.
2. Newman, M. C. and W. H. Clements, 2008: Ecotoxicology- A comprehensive treatment, CRC press.
3. Wright, D. A. and P. Welbourn, 2002. Environmental toxicology, Cambridge University press.
4. Willium P. L. and J. L. Burson, 1985. Industrial toxicology, safety and health applications in the workplace, Van Nostard Reinhold, New York.
5. Girard, J. E. 2015. Principles of Environmental chemistry. 3rd Ed. Jones & Barllett learning, New Delhi.
6. Walker, C. 2014. Ecotoxicology. CRC Press.
7. Jorgensen, SE. 2016. Ecotoxicology and Chemistry Applications in Environmental Management. CRC Press.
8. Lu F.C. & S Kacew 2002. Lu's Basic Toxicology. CRC Press.
9. Santra S. C. Environmental Science. New Central Book Agency.

DISCIPLINE SPECIFIC ELECTIVE 02 (Code: UG-ENVS-H-DSE-02a)
ENVIRONMENTAL ECONOMICS

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-DSE-L -02a **CREDITS: 4; Lectures-60**

Unit 1: Introduction to microeconomics

Definition and scope of environmental economics; environmental economics versus traditional economics; brief introduction to major components of economy: consumer, firm and their interaction in the market, producer and consumer surplus, law of demand and supply, utilitariasm; Pareto optimality; compensation principle.

Unit 2: Environmental economics

Main characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Hardin's Thesis of 'The Tragedy of Commons'; methods of abatement of externalities.

Unit 3: Economic solutions to environmental problems

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

Unit 4: Natural resource economics

Economics of non-renewable resources; economics of renewable resources; economics of water use, management of fisheries and forests; introduction to natural resource accounting.

Unit 5: Tools for environmental economic policy

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

UG-ENVS-H-DSE-P -02a **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Valuation of a forest/wetland- model exercise.
- Field visit for evaluation of forest and fisheries management system and document preparation.

Suggested Readings

1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B. O., Levin, S., Maler, K. G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. *Ecological Economics* 15: 91-95.
2. Hanley, N., Shogren, J. F., & White, B. 2007. *Environmental Economics: In Theory and Practice*. Palgrave Macmillan.
3. Kolstad, C. D. 2010. *Environmental Economic*s. Oxford University Press.
4. Perman, R. 2003. *Natural Resource and Environmental Economics*. Pearson Education.
5. Singh, K. & Shishodia, A. 2007. *Environmental Economics: Theory and Applications*. Sage Publications.
6. Thomas, J. M. & Callan, S. J. 2007.*Environmental Economics*. Thomson Learning Inc.
7. Tietenberg, T. 2004. *Environmental and Natural Resource Economics* (6^{th} Edition). Pearson Education Pvt. Ltd.
8. Tietenberg, T. H. & Lewis, L. 2010. *Environmental Economics and Policy*. Addison-Wesley.
9. Turner, R. K., Pearce, D., & Bateman, I. 1994. *Environmental Economics: An Elementary Introduction*. Harvester Wheatsheaf.

-OR-

DISCIPLINE SPECIFIC ELECTIVE 02 (Code: UG-ENVS-H-DSE-02b)

WASTE AND WASTEWATER MANAGEMENT

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

Preamble: Every human activity ends up in the generation of unwanted waste product. This paper throws light on the current scenario of waste and waste water generation, problems in handling and management. It also deals with the different governmental policies for proper management in order to minimize their effect on environment.

UG-ENVS-H-DSE-L -02b **CREDITS: 4; Lectures-60**

Unit 1: Waste water treatment

Sources and generation of waste water; physicochemical and biological properties; primary, secondary and advanced treatment strategies (domestic/municipal and industrial wastewater treatment). Standards for wastewater discharge; reuse and recycling.

Unit 2: Effect of solid waste disposal on environment

Definition, Types, characterization and chemical composition. Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; municipal solid waste; hazardous waste and biomedical waste, mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

Unit 3: 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.

Unit 4: Industrial waste management

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

4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment. Waste- to- energy (WTE) - concept; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Unit 6: Integrated waste management

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

Unit 7: Policies for solid waste management

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

UG-ENVS-H-DSE-L -02b **CREDITS: 2**

Practical:

- Physico-chemical characterisation of waste water (TSS, TDS, oil & grease, phenolics).
- Sludge characterisation (moisture content, ash, VOC, metal etc.).
- Visit to waste disposal sites and report preparation.

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 Life cycle 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.

CORE COURSE 13 (Code: UG-ENVS-H-CC-13)

ENVIRONMENTAL LEGISLATION AND POLICY

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06.

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

UG-ENVS-H-CC-L -13 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

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.

Unit 2: History of environmental legislation and policy

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

Unit 3: Environmental legislation

Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

Unit 4: Legislative instruments

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

Unit 5: Government institutions

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

Unit 6: Case studies

National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; environmental education case: M.C. Mehta vs. Union of India, WP 860/1991.

Unit 7: International laws and policy

Ramsar convention, 1971; 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.

UG-ENVS-H-CC-P -13 **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Field visit for assessment of environmental policy adoption, environment safety policy adoption in industry and document preparation.
- Survey on perception of environmental laws in communities/ societies and document preparation.

Suggested Readings

1. Agarwal, V. K. 2005. Environmental Laws in India: Challenges for Enforcement. *Bulletin of the National Institute of Ecology* 15: 227-238.
2. Divan, S. & Rosencranz, A. 2002. *Environmental Law and Policy in India: Cases, Materialsand Statues* (2nd edition). Oxford University Press.
3. Gupta, K. R. 2006. *Environmental Legislation in India*. Atlantic Publishers and Distributors.
4. Shastri, S. C. 2015. Environmental Law. Eastern Book Company.
5. Leelakrishnan, P. 2008. *Environmental Law in India* (3rd edition). Lexis Nexis India.
6. Venkat, A. 2011. *Environmental Law and Policy*. PHI Learning Private Ltd.

CORECOURSE-14 (Code: UG-ENVS-H-CC-14)

URBAN ECOSYSTEMS

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-CC-L -14 **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Introduction to urbanization; urban sprawl and associated environmental issues.

Unit 2: Environment in an urban setting

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

Unit 3: Urban dwelling

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

Unit 4: Urban interface with the environment

Management of urban environment; alternative resources; policy and management decisions; urban settings as loci of sustainability; challenges associated with sustainability and urban future.

Unit 5: Natural spaces in a city

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

Unit 6: Planning and environmental management

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

UG-ENVS-H-CC-P -14 **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Exercises: Students will carry out a group work in which the development of the infrastructure of the city of the future is explored and presented. The assignment concentrates on the development of one infrastructure (clean water, waste water or energy) in two possible surroundings (newly built city or transition from present to future situation).
- Tutorial focusing on introducing the state-of-the-art technologies for drinking water supply, wastewater treatment, energy supply and material/nutrient recycling and recovery.
- Individual assignment the student will perform a technological assessment for the solution of a specific urban environmental problem performing basic calculations on urban flows and their transformations and considering the sustainability outcome.
- Field visits to experience various environmental technologies working in practice.

Suggested Readings

1. Niemelä, J., Breuste, J. H., Guntenspergen, G., McIntyre, N. E., Elmqvist, T., James, P. (eds) (2011) Urban Ecology. Patterns, Processes, and Applications. Oxford University Press: UK.
2. Van Bueren, E. M, van Bohemen, H., Itard, L., Visscher, H. (Eds). (2011) Sustainable Urban environment. An ecosystem approach. Springer.
3. D'Monte, Darryl. 1985. *Industry versus Environment Temples or Tombs*. Three Controversies, Delhi, CSE.
4. Gaston, K. J. 2010. *Urban Ecology*. Cambridge University Press, New York.

6. Montgomery, M. R. 2009. Urban Transformation of the developing world. *Science* 319: 761-764.
7. Richter, M & Weiland, U. (ed.) 2012. *Applied Urban Ecology*. Wiley-Blackwell, UK.

DISCIPLINE SPECIFIC ELECTIVE 03 (Code: UG-ENVS-H-DSE- 03a)

NATURAL HAZARDS AND DISASTER MANAGEMENT

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

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

UG-ENVS-H-DSE-L -03a **CREDITS: 4; Lectures-60**

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, epicentre; 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 and vulnerability assessment.

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.

UG-ENVS-H-DSE-P -03a **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Visit to disaster prone/ affected areas and submission of report.
- Mock drill for emergency preparation of fire hazard.
- Preparation of a report on vulnerability and risk assessment, and safety measures to be adopted in the study area.

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.

-OR-

DISCIPLINE SPECIFIC ELECTIVE 03 (Code: UG-ENVS-H-DSE-03b)

INSTRUMENTAL TECHNIQUES FOR ENVIRONMENTAL ANALYSIS

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

Preamble: This paper introduces the students to various instrumental techniques for environmental analysis along with their principle and applications. An attempt will be made to have a compressive idea about various sampling techniques along with sample preparation. The students will also be introduced to the concept of radioactivity detection techniques and their applications.

UG-ENVS-H-DSE-L -03b **CREDITS: 4; Lectures-60**

Unit 1: Introduction

Instrumental methods for environmental analysis.

Unit 2: Principle and application

Titrimetric, gravimetric, potentiometric, nephelometry, turbidimetry, spectrophotometry, spectro-fluorimetry, flame photometry, atomic absorption spectrometry, inductively coupled plasma mass spectrometry, chromatographic techniques, gel electrophoresis, gas chromatography.

Unit 3: Water and Soil sampling techniques and sample preparation

Sampling methods, sample preservation, storage and processing techniques.

Unit 4: Air quality sampling and analysis

Air samplers, air sampling design, air sampling techniques and application, biomonitoring.

Unit 5: Noise monitoring

Techniques for measurement of noise level; Abatement and protective measures

Unit 6: Radioactivity

Detection techniques and application.

UG-ENVS-H-DSE-P -03b **CREDITS: 2**

Practical: Field survey based analysis, exercise and interpretation

- Principles and application of instruments and document preparation.
- Demonstration of selected instruments and document preparation.

Suggested Readings

1. Instrumental methods of chemical analysis - Chatwal G. R. and S. K. Anand, 2005, Himalayan Pub. House, Mumbai.
2. Standard Methods for the Examination of water & Waste Water – 21st Edition 2005, APHA.

DISCIPLINE SPECIFIC ELECTIVE 04 (Code: UG-ENVS-H-DSE-04)

DISSERTATION

FULL MARKS: 75, CREDITS: 4 (L) + 2(P) = 06

UG-ENVS-H-DSE-L -04 **CREDITS: 2**

Dissertation

A dissertation has to be prepared on consultation with teachers/mentors on a topic from any area of Environmental Science. During examination a thorough viva-voce will be conducted by the examiners / adjudicators. The dissertation will be evaluated on the basis of written documents submitted by the candidate, originality and importance.

UG-ENVS-H-DSE-P -04 **CREDITS: 2**

Practical

A power point presentation has to be prepared and a short oral presentation will be considered for continuous evaluation. A PDF file/print copy of the power point will be required to be submitted.

ABILITY ENHANCEMENT COMPULSORY COURSE (Code: UG-ENVS-H-AECC-02)

ENVIRONMENTAL STUDIES

FULL MARKS: 50, CREDITS: 02

Unit 1: Introduction to environmental studies

Multidisciplinary nature of environmental studies;

Scope and importance; Concept of sustainability and sustainable development.

Unit 2: Ecosystems

What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems:

- Forest ecosystem
- Grassland ecosystem
- Desert ecosystem
- Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: Natural Resources: Renewable and Non-renewable Resources

- Land resources and landuse change; Land degradation, soil erosion and desertification.
- Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.
- Water : Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).
- Energy resources : Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 4: Biodiversity and Conservation

- Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots.
- India as a mega-biodiversity nation; Endangered and endemic species of India.
- Threats to biodiversity : Habitat loss, poaching of wildlife, man---wildlife conflicts, biological invasions; Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity.
- Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 5: Environmental Pollution

- Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution.
- Nuclear hazards and human health risks.
- Solid waste management: Control measures of urban and industrial waste.
- Pollution case studies.

Unit 6: Environmental Policies & Practices

- Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture.

- Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).
- Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Unit 7: Human Communities and the Environment

- Human population growth: Impacts on environment, human health and welfare.
- Resettlement and rehabilitation of project affected persons; case studies.
- Disaster management: floods, earthquake, cyclones and landslides.
- Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan.
- Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.
- Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

Unit 8 Field work

- Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc.
- Visit to a local polluted site---Urban/Rural/Industrial/Agricultural.
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems---pond, river, Delhi Ridge, etc.

Suggested Readings:

1. Carson, R. 2002. Silent Spring. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R.1993. This Fissured Land: An Ecological History of India. Univ. of California Press.
3. Gleeson, B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.
4. Gleick, P. H. 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
5. Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll. Principles of Conservation Biology. Sunderland: Sinauer Associates, 2006.
6. Grumbine, R. Edward, and Pandit, M. K. 2013. Threats from India's Himalaya dams. Science, 339: 36-37.
7. McCully, P. 1996. Rivers no more: the environmental effects of dams (pp. 29-64). Zed Books.
8. McNeill, John R. 2000. Something New Under the Sun: An Environmental History of the Twentieth Century.
9. Odum, E. P., Odum, H. T. & Andrews, J. 1971. Fundamentals of Ecology. Philadelphia: Saunders.
10. Pepper, I. L., Gerba, C. P. & Brusseau, M. L. 2011. Environmental and Pollution Science. Academic Press.
11. Rao, M. N. & Datta, A. K. 1987. Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd.
12. Raven, P. H., Hassenzahl, D. M. & Berg, L. R. 2012. Environment. 8th edition. John Wiley & Sons.
13. Rosencranz, A., Divan, S., & Noble, M. L. 2001. Environmental law and policy in India. Tripathi 1992.
14. Sengupta, R. 2003. Ecology and economics: An approach to sustainable development. OUP.
15. Singh, J. S., Singh, S. P. and Gupta, S. R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.

16. Sodhi, N. S., Gibson, L. & Raven, P. H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.

17. Thapar, V. 1998. Land of the Tiger: A Natural History of the Indian Subcontinent.

18. Warren, C. E. 1971. Biology and Water Pollution Control. WB Saunders.

19. Wilson, E. O. 2006.The Creation: An appeal to save life on earth. New York: Norton.

20. World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press.