Department of Environmental Science
University School of Vocational Studies and Applied Sciences
Guatam Buddha University

M.Sc. PROGRAMME IN ENVIRONMENTAL SCIENCE

The programme is spread over four semesters. It carries 92 credits and comprises of five components, viz., Teaching (Course work), Laboratory (Experiments), Field visit, Seminar and Project. The credits are distributed as follows:

Total Credits=92
Teaching (Course Work) = 65
Laboratory (Experiments) =12
Field visit = 02
Seminar = 01
Project=12

TEACHING (COURSE WORK)

This is the principal component of the programme which includes three different types of course, as follows:

Core Courses: These are key courses offered by the Department of Environmental Science. *All core courses are compulsory.*

Discipline Specific Elective Courses (DSE): These courses are also offered by the Department of Environmental Science. The DSE-I and II courses are scheduled only for Semester -I and semester-II, respectively. *The learner has a choice to choose any one course out of DSE-I and DSE-II courses in Semester-I and Semester-II, respectively*.

Generic Elective-I Courses (GE-I): These courses are offered by the other Departments of the University. *The learner has a choice to choose any one course out of Generic Elective-I courses in Semester-II only*.

The distribution of credits for Teaching (Course work) is given below:
Total Teaching (Course Work) =65

Core Courses =56
Discipline Specific Elective -I Course (DSE-I)=3
Discipline Specific Elective-II Course (DSE-II)=3
Generic Elective -I Course (GE -I)=3

LABORATORY (EXPERIMENTS)

The Laboratory work is spread over in three semesters -Semester-I, Semester-II and Semester-III. The Experiments are designed specifically considering the Course work and carried out in the Environment Science Laboratory -I and Laboratory II. Necessary changes in the experiments laid out may be done during the semester(s) also as per the academic requirement and availability of facilities.

FIELD VISIT

To develop observational skills and action-oriented skills as demanded in the real life situations or field conditions and for theory practice linkage, the learners are encouraged to visit field (Credit course) in diverse areas of environmental studies. *It is scheduled for Semester*-I .The learners are also motivated to undertake such activities in other semesters too as a non- credit component.

SEMINAR

It is a Credit course scheduled for Semester-IV .Each learner is free to choose a topic of her/ his choice of relevance to environment or s/he may consult faculty members in the Department of Environmental Science for selection of the topic. The learner is expected to present the work through Power Point in the mid of the Semester-IV. Submission of a hard copy (to the Faculty Coordinator of the course) of the work done on the topic chosen for seminar is *mandatory* before oral presentation.

PROJECT

Doing a masters project is much more than a skill- based exercise. It allows a learner to experience a series of high level educational, intellectual and ethical issues which help her or him to grow as person and a professional. Its purpose is to provide a learner the opportunity to demonstrate her or his " *mastery* " of skills of analysis, synthesis, evaluation, argumentation, data collection and handling by applying them to a specific topic. In addition, there are other skills, such as, writing qualities e.g., determination and attitudes, such as, honesty which are necessary in the professional life. Project component of the M.Sc. programme is, thus, an attempt to *technical mastery* in a learner of the field of specialization, capable of doing independent scholarly work, and able to formulate conclusions that will in some respect enlarge or modify what has been previously known. The learner will normally have the option of "*Literature Review Project*" or the "*Field Survey or Experiment-based Project*" related to basic and applied aspects of environment and sustainable development. *Selection of the topic, therefore, needs to be considered carefully focusing on environmental issues*.

COURSE CONTENTS OF M.Sc. PROGRAMME

The details of the contents of the courses of the M.Sc. Programme semester-wise are as follows:

Programme Structure: M. Sc. Environmental Science (CBCS-based)					
S. No.	**Course Code**	**Course Name**	**Course Category**	**L-T-P**	**Credit**
SEMESTER- I					
1.	ES 401	Fundamentals of Environmental Science	Core	3-0-0	3
2.	ES 403	Environmental Chemistry	Core	3-0-0	3
3.	ES 405	Environmental Biology	Core	3-0-0	3
4.	ES 407	Introduction to Environmental Modelling	Core	2-0-0	2
5.	ES 409	Natural Hazards	Core	3-0-0	3
6.	ES 415	Energy and Environment	Core	3-0-0	3
7.		**Discipline Specific Elective-I (Any one course)**	**DSE-I**	3-0-0	3
		PRACTICALS			
8.	ES 411	Laboratory-I*	Core	0-0-8	4
9.	ES 413	Field Visit	Core	0-0-4	2
		Total L-T-P		**20-0-12**	**26**
		Total Contact Hours		**32**	
SEMESTER- II					
1.	ES 402	Earth Resources and Processes	Core	3-0-0	3
2.	ES 406	Soil Science	Core	3-0-0	3
3.	ES 408	Environmental Pollution and Human Health	Core	4-0-0	4
4.	ES 410	Climatology and Global Climate Change	Core	3-0-0	3
5.	ES 412	Hydrology	Core	3-0-0	3
6.		**Discipline Specific Elective-II (any one course)**	**DSE-II**	3-0-0	3
7.		**Generic Elective-I (Any one course)**	**GE-I**	3-0-0	3
		PRACTICALS			

8.	ES 414	Laboratory-II*	Core	0-0-8	**4**
		Total L-T-P		**22-0-8**	**26**
		Total Contact Hours		**30**	
SEMESTER- III					
1.	ES 501	Environmental Toxicology and Bioremediation	Core	3-0-0	3
2.	ES 503	Biodiversity and Environmental Conservation	Core	4-0-0	4
3.	ES 505	Remote Sensing and Geographic Information System	Core	3-0-0	3
4.	ES 507	Waste Management	Core	3-0-0	3
5.	ES 509	Environmental Impact Assessment and Sustainable Development	Core	3-0-0	3
6.	ES 511	Advanced Analytical Techniques for Environmental Monitoring	Core	4-0-0	4
7.	ES 513	Research Methodology	Core	3-0-0	3
		PRACTICALS			
8.	ES 521	Laboratory-III*	Core	0-0-8	4
		Total L-T-P		**23-0-8**	**27**
		Total Contact Hours		**31**	
SEMESTER- IV					
1.	ES 502	Seminar	Core	0-0-2	1
2.	ES 506	Project	Core	0-0-24	12
		Total L-T-P		0-0-26	**13**
		Total Contact Hours		**26**	
	Total Credits for all Semesters				**92**

Generic Elective-I (GE-I) **(Select any one course only)**					
1.	FT 312	Food Processing Waste Management	**GE-I**	3-0-0	3
2.	UP102	Settlement Planning	**GE-I**	3-0-0	3
Discipline Specific Electives-I (DSE-I) **(Select any one course only)**					
1.	ES 417	Disaster Management	**DSE-I**	3-0-0	3
2.	ES 421	Urban Green Space Management	**DSE-I**	3-0-0	3
3.	ES 423	Oceanography	**DSE-I**	3-0-0	3
Discipline Specific Electives-II (DSE-II) **(Select any one course only)**					
1.	ES 416	Environmental Planning, Policy, Convention and Legislation	**DSE-II**	3-0-0	3
2.	ES 418	Microbial Ecology	**DSE-II**	3-0-0	3
3.	ES 420	Agro-ecology and Agro-forestry	**DSE-II**	3-0-0	3
**Experiments will be based on course contents*					

COURSE STRUCTURE
SEMESTER-I

ES- 401 FUNDAMENTALS OF ENVIRONMENTAL SCIENCE
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To provide substantive knowledge of understanding of environmental science, Earth environment, environmental factors, ecosystem, environmental issues and challenges, and social perspective of environment

OUTCOME

The learners will acquire basic knowledge about environment and environmental science to develop analytical perspective and technical skills from other courses for conservation and quality environment

CONTENTS

Environmental Science- Definition, nature and scope, Difference between environmental science and environmental studies; The Earth's environment (Ecosphere) and its components (atmosphere, hydrosphere, lithosphere (geosphere) and biosphere), Human activities and Earth; Global (climate change, biodiversity loss, acid rain, depletion of ozone layer and pollution of international waters) and national environment issues

Environmental Factors- Geographical (Topography, altitude and aspect, geographical land forms-*Shiwalik*, *doon*, *bhabhar* and *tarai*), Physical (Light, temperature, pressure, precipitation and wind). Chemical (gases and pollutants) and Biological (aerospora and pathogens)

Ecosystem- Concept, types and importance; Structure-trophic levels, homeostasis, food transfer (food chain and web, detritus pathway); Functions (biogeochemical cycles-C, N, P and S) and energy flow (Laws of thermodynamics, pathway of energy), Ecological pyramids; Ecosystem perturbations (grazing, browsing, trampling, burning and industrialization)

Environmental Resources- Land (minerals and soil), Water (fresh water and marine), Wetland Energy (conventional and new and renewable) and biological; Natural resources (Forest, Grassland, Wetland): Structure, distribution, exploitation and environment-related concerns; Forest degradation and distribution, exploitation infectious diseases; Conservation of non-renewable resources

Social Perspective of Environment-Social impacts of growing human population and effluence, hunger and malnutrition, famine and poverty; Food security and sustainability; Social impacts of water crisis, floods and droughts; Social impacts of dams and other development projects (e.g., infrastructure, mining, human rehabilitation issues etc.)

Environmental Education- Concept, objectives and approaches, Role of adult and women education, Role of ICT

SUGGESTED READINGS

Botkin, D.B. and Keller, E.A 2002. *Environmental Science: Earth as Living Planet*, John Wiley and Sons, New York.

Chiras, D. D. 1985. *Environmental Science*, The Benjamin/Cumrouings Publishing Co. Inc., Menlo Park.

Cunningham, W.P. and Saigo, B.W. 1999. *Environmental Science: A Global Concern*, WCB-McGraw Hill Companies Inc., USA.

Khoiyangbam, R.S. and Gupta N. (eds.). 2017. *Introduction to Environmental Sciences*, The Energy and Resources Institute, New Delhi, 426 p.

Marten, G. 2001. *Human Ecology-Basic Concepts for Sustainable Development*, Earthscan Publications, UK.

Miller, G.T. Jr. 2004. *Environmental Science*: *Working with Earth*, Thomson Brooks/Cole Publication (International Students Edition), U.K.

Miller, G.T. Jr. and Spoolman, S.E. 2010. *Environmental Science*, Cenage Learning, U.K.

Nebel, B.J. 1981. *Environmental Science*: *The Way The World Works*, Prentice Hall, Englewood Cliffs, NJ07632

Odum, E.P. and Gray, B.W. 2004. *Fundamentals of Ecology*, Cengage Learning, USA.

Santra, S.C. 2016. *Environmental Science*, New Central Book Agency (P.) Ltd., Kolkata.

Singh J.S., Singh, S.P. and Gupta, S.R. 2007. *Ecology, Environment and Resource Conservation*, Anamaya Publishers, New Delhi.

COURSE STRUCTURE
SEMESTER-I

ES 403 ENVIRONMENTAL CHEMISTRY
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To paraphrase basics of environmental chemistry, green chemistry and toxic chemicals

OUTCOME

The learners would be able to apply the knowledge in enhancing the quality of environment and sustainable use

CONTENTS

Fundamentals of Environmental Chemistry: Classification of elements, stoichimetry, Gibb's energy, Chemical Bonding, Chemical reactions and equations; Organic functional groups, classes of organic compounds; Free radical reactions, catalytic processes; Chemical equilibria, Acid base reaction, Solubility products, Solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, radioisotopes; Principles of green chemistry

Atmospheric Chemistry: Particles, ions reactive intermediates in atmosphere like hydroxyl radical, ozone and nitrate radical; Chemical speciation, chemical processes in the formation of inorganic and organic particulate matters, Thermo-chemical and photo-chemical reactions in atmosphere,Oxygen and ozone chemistry, photochemical smog

Aquatic Chemistry: Chemistry of natural waters (fresh water and marine), physico-chemical properties of water; Sedimentation, coagulation, flocculation, filtration, pH and redox potential, Water pollution: Deoxygenating substances, influence of chemical processes on DO, BOD and COD, solubility of CO_2; effect of pH, nitrogen and phosphorus transformations, salinity; Eutrophication, oxygen sag curve, seasonal variations and vertical profiles of dissolved oxygen

Chemistry of Toxic Products: Pesticides-Classification and their effects, Bio-chemical aspects of heavy metals (Hg, Cd, Pb, and Cr) and metalloids (As and Se), CO, O_3, PAN, VOC, and POP, Carcinogens in air

SUGGESTED READINGS

Baird, C. and Cann, M. 2005. *Environmental Chemistry*, Freeman Publishers, London.

Connell, D.W. 2005. *Basic Concepts of Environmental Chemistry*, CRC Press, New York.

Dara, S.S. and Mishra, D.D. 2010. *A Text Book of Environmental Chemistry and Pollution Control*, S. Chand and Co. Ltd., New Delhi, 522 p.

Manahan, S.E. 2010. *Environmental Chemistry*, Lewis Publishers, U.K.

Masters, G.M. and Ela W.P. 2008. *Introduction to Environmental Science and Engineering*, PHI Learning, New Delhi.

Stumm, W. and Morgan, J. J. 1996. *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*, Wiley Hoboken, New Jersey, USA.

Website

https://www.epa.gov/2.

COURSE STRUCTURE
SEMESTER-I

ES 405 ENVIRONMENTAL BIOLOGY
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To provide substantive knowledge of fundamentals of ecology and microbial ecology as basis for environmental studies and conservation

OUTCOME

The learners will develop an indepth understanding of functioning of nature, human-induced systems and interrelationships in community and ecosystems

CONTENTS

Ecology-Definition, Ecology as an interdisciplinary science, classification, importance; Human ecology-Concept, human settlement, origin of life and speciation; Tolerance range and adaptations-Liebig's law of minimum, The law of tolerance; Phenotypic plasticity, ecosystems and ecoclines, acclimation, Adaptation strategies in plants and animals

Population- Definition, characteristics, population growth and regulations, population-resource relationship, concept of carrying capacity, population fluctuations, dispersion and metapopulation, Life history strategies, r-and k selection (species), key stone species, bioindicator species; Population dynamics, models for single and interacting populations, stable points, stable cycles, chaos competition, prey predation

Community Ecology- Definition, community concept, Analytical and synthetic characters like physiognomy, stratification (vertical and horizontal), species composition, niche, interactions (predation, herbivory, parasitism, symbiosis and allelopathy), species diversity and stability, edge effect and ecotone, continuum

Ecological Succession- Definition, Types, Mechanism of succession; changes involved in succession, Climax-Concept and types; Restoration ecology-Concept and importance, Restoration of degraded ecosystems and lakes

Industrial Ecology- Concept and practices

Biomes- Concept, classification and distribution; Major terrestrial biomes, fresh water ecosystems, Marine ecosystems, characteristics of different biomes-tundra, grassland, deciduous forest biome, tropic rain forest, savanna, chapparal

Microbial Ecology

Definition, microbial metabolism and microbial interaction; Biochemistry of biological nitrogen fixation and other metabolic pathways in terms of enzymology; Microbial toxicns and environmental hazards, Microbially- included corrosions and biofilms; Microbes in environmental protection- bioremediation, waste water treatment, microbes as regulator of atmospheric trace gases

SUGGESTED READINGS

Dodson, S.I. 1999 *Readings in Ecology*, Oxford University Press, New Delhi.

Huston, M. A. 1994 *Biological Diversity: The Coexistence of Species*, Cambridge University Press, Cambridge.

Michael, B., Townsend R.C. and Harper L. J. 2005. *Ecology: From Individuals to Ecosystems*, Willey-Blackwell.

Nierengberg, W.A. 1995. *Encyclopedia of Environmental Biology*, Vols 1-3, Academic Press, New York.

Odum, E.P. and Gray, B.W. 2004. *Fundamentals of Ecology*, Cengage Learning, USA.

Pain, A. K. and Hazra, S. 2008. *Industrial Ecology: Concepts and Practices*, The Icfai University Press, Agartala.

Pelczar, M. J. Chan, E.C.S. and Krieg, N.R. 2002. *Introduction to Microbiology*, Tata McGraw-Hill Co. Pvt. Ltd., New Delhi.

Prescott, L. Harley, J. and Klein, D. 2002. *Microbiology*, Tat McGraw-Hill Co. Pvt. Ltd., New Delhi.

Ricklefs, R.E. and Miller, G. 2000. *Ecology* W.H. Freeman.

Sharma, P.D. 2017-18. *Ecology and Environment* (13th Edn.), Rastogi Publications, Meerut, 755 p.

Singh J.S., Singh, S.P. and Gupta, S.R. 2007. *Ecology, Environment and Resource Conservation*, Anamaya Publishers, New Delhi.

Singh, H. R. 2005. *Environmental Biology*, S. Chand and Co. P. Ltd., New Delhi.

Singh, J.S., Singh S. P. and Gupta S. R. 2008. *Ecology, Environment and Resource Conservation*, Anamaya Publishers, New Delhi, 688 p.

Singh. J.S., Singh S.P. and Gupta, S.R. 2014. *Ecology, Environmental Science and Conservation*, S. Chand Publications, New Delhi.

Smith, T.M. and Smith, R.l. 2008. *Elements of Ecology*, Pearson, New Delhi.

COURSE STRUCTURE
SEMESTER-I

ES 407 INTRODUCTION TO ENVIRONMENTAL MODELLING
CREDIT: (L–T–P): 2 (2-0-0)

OBJECTIVE

To provide fundamental knowledge about environmental modeling in regard to pollutants dispersion and forecasting

OUTCOME

The learners would be able to apply the knowledge so understood in developing models related to environmental pollution

CONTENTS

Approaches to development of environmental models; Linear, simple and multiple regression models; Validation, forecasting and time series; Model of population growth and interaction - Lotka-Volterra model, Leslie's matrix model; Point source stream pollution model, Box Model (including line and area source model), Gaussian plume model

SUGGESTED READINGS

Masters, G.M. 2008. *Introduction to Environmental Engineering and Science*, Prentice Hall, New Delhi.

Smith, J. and Smith, P. 2007. *Environmental Modelling: An Introduction*, Oxford University Press Inc., New York.

Wainwright, J. and Mulligan, M. 2013. *Environmental Modelling: Finding Simplicity in Complexity*, 2nd Edition, John Wiley and Sons Inc., New Jersey.

COURSE STRUCTURE
SEMESTER-I

ES 409 NATURAL HAZARDS
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To understand natural hazards, causes of their occurrence, effects of their occurrence on environment, life and property, and risk management

OUTCOME

The learners would be able to develop a comprehensive view on natural hazards and risk management

CONTENTS

Natural Hazards: Definition, classification (types of hazard), risk and vulnerability causes (continental drift, plate tectonics, sea floor spreading, isostasy); Detailed description on causes, distribution, effects and mitigation measures concerning natural hazards, viz., earthquake, tsunami, volcanic eruption, cyclone, flood, tornado and hail, cloudburst, drought, avalanche, landslide, cold and heat hazard, forest fire, coastal erosion and sea-level changes; distribution pattern and consequences of natural hazards

Risk Assessment: Hazard identification, hazard accounting, scenarios of exposure, risk characterization and risk management (hazard mitigation)

SUGGESTED READINGS

Bolt, B.A., Horn, H.L., MacDonald, G.A. and Scott, R.F. 2015. *Environmental Hazards*, Springer-Verlag, Berlin.

Bryant, E. A.1991. *Natural Hazards*, Cambridge University Press, Cambridge.

Keller, E.A. and Devecchio, D.E. 2014. *Natural Hazards: Earth's Processes as Hazards, Disasters and Catastrophes* (4th Edition), Pearson Publishers, New Delhi.

Singh, R and Bartleu, D, 2018. *Natural Hazards: Earthquakes, Volcanoes and Landslides*, CRC Press, New York.

COURSE STRUCTURE

SEMESTER-I

ES 415 ENERGY AND ENVIRONMENT
CREDIT: (L–T–P): 3 (3-0-0)

OBJECTIVE

To provide in-depth knowledge of renewable and non-renewable energy resources, their harnessing techniques and energy-environment issues

OUTCOME

The knowledge so gathered could be utilized to meet the challenges of energy vis-a-vis environmental security

CONTENTS

Sun as Source of Energy- Nature of its radiation, solar radiation and its spectral characteristics; Conventional energy sources (coal, oil, biomass and natural gas), Non-conventional energy sources (hydro-electric power, tidal, wind, geothermal, solar, nuclear magneto-hydrodynamic power MHD); Energy use pattern in India and parts of world, Energy security

Fossil Fuels: Classification, composition, physico-chemical characteristics; Calorific value – gross and net; Energy content of coal, petroleum and natural gas, shale oil, coal bed methane, gas hydrates

Concept of Green Energy; Principles of generation of hydro-power, tidal energy, ocean thermal energy conversion, wind power, geothermal energy, solar energy (solar collectors, photo-voltaic modules, solar ponds)

Nuclear Energy - Fission and fusion, Nuclear fuels, Nuclear reactor – principles and types; Mechanism of radiation action on living organisms - Stochastic and Non-stochastic effects, delayed effects; Radioactivity from nuclear reactors, fuel processing and radioactive waste, hazards related to power plants

Bioenergy: Types, importance, methods of energy production from biomass

Environmental Implications of Energy Use; CO_2 emission and atmosphere –scenario in developed and developing world (and India), Global warming, Radiative forcing, Impacts of large scale exploitation of solar, wind, hydro, nuclear and bio-energy sources; National Solar Mission, National Mission for Enhanced Energy Efficiency, case studies.

SUGGESTED READINGS

Fay, J.A. and Golomb, D.S. 2011. *Energy and the Environment*, Oxford University Press, New Delhi.

Iqbal, M. 1983. *An Introduction to Solar Radiation*. Academic Press, New York.

Kaushika, N.D. and Kaushik, K. 2004. Energy, *Ecology and Environment: A Technological Approach*, Capital Publications, New Delhi.

***Website** - https://nptel.ac.in/course.html*

COURSE STRUCTURE
SEMESTER-I

ES 411 LABORATORY – I
CREDIT : L–T–P : 4 (0–0–4)

OBJECTIVE

To provide opportunity to learners for hands-on practice on environment-related knowledge inputs as provided to them in courses during classroom learning in the first semester

OUTCOME

To learners would be able to appreciate and realize the importance of practice for theory courses-related inputs, and develop practical skills of analyzing environment and environmental factors

CONTENTS

S. No.	Experiment
1.	To estimate pH and electrical conductivity of given water and soil samples
2.	To determine total dissolved solids and salinity of given water/wastewater samples
3.	To determine the turbidity of given water/wastewater samples
4.	To determine alkalinity and total hardness in given water/wastewater samples
5.	To determine Dissolved Oxygen (DO) in given water/wastewater samples
6.	To determine Biochemical Oxygen Demand (BOD) in given water/wastewater samples
7.	To determine Chemical Oxygen Demand (COD) in given water/wastewater samples
8.	To verify Beer-Lambert's law using spectrophotometer
9.	To determine nitrate and nitrite in given water/wastewater samples
10.	To determine phosphate in given water/wastewater samples
11.	To determine chloride and fluoride in given water/wastewater samples
12.	To determine oil and grease in given wastewater samples
13.	To estimate ammonia in given water/wastewater samples
14.	To determine free carbon di oxide in given water/wastewater samples
15.	To determine heavy metals (Pb, Hg, Zn, Cr, and Cd) in given water/wastewater samples
16.	To understand working and handling of autoclave and Laminar Air Flow chamber
17.	To enumerate coliform bacteria in given water sample by MPN method
18.	To isolate and enumerate bacteria from wastewater using serial dilution agar plate method
19.	To isolate fungi from wastewater using serial dilution agar plate method
20.	To perform Gram staining of given bacterial culture
21.	To perform lacto-phenol cotton blue mounting of fungi
22.	To determine bacterial growth using spectrophotometer

SUGGESTED READINGS

Aneja, K.R. 2018. *Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology*, 5th Edition, New Age International (P.) Ltd. Publishers, New Delhi

APHA.1997. *Standard Methods for Examination of Water and Wastewater*, 21st Edition, American Public Health Association, American Water Works Association and Water Pollution Control Foundation, Washington, D.C.

Jackson, M.L. 1998. *Soil Chemical Analysis*, Revised Edition, Prentice Hall London.

Kapur, P. and Govil, S.R. 2004. *Experimental Plant Ecology*, CBS Publishers and Distributors, New Delhi, 154 p.

Piper, C.S. 1995. *Soil and Plant Analysis*, Revised Edition, University of Adelaide, Australia.

Trivedi, R.K. Goel, R.K. and Trisal, C.L. 1998. *Practical Methods in Ecology and Environmental Science*, Revised Edition, Environmental Publications, Karad.

COURSE STRUCTURE
SEMESTER-I

ES 413 FIELD VISIT
CREDIT: (L-T-P): 2 (0-0-2)

OBJECTIVE

To create a broad understanding of environment, environment-human interactions and environmental conservation-oriented initiatives among learners, and promote their observation and action-oriented real-life skills

OUTCOME

The learners would be able to correlate field/real-life-based issues and practices concerning environment, environment-human interactions and conservation initiatives with the knowledge and technology inputs as provided to them in the theory and laboratory courses.

CONTENTS

(A) Field Visit to Upscale Real-life Observation Skills

- An open-ended exercise on "Know your surroundings/campus" to understand the surroundings/campus environment, environment-friendly measures adapted and their impacts
- To observe vegetation in a part of campus to understand species composition, species habit and phenology
- To understand morphological responses of species to environmental factors, such as, human stress and stress caused by poor soil fertility, moisture deficiency and temperature, etc.
- To study bioindicator species in the campus
- To study invasive alien species in the campus
- To study green belt and avenue plantations
- Field demonstration of aquaculture
- Visit of Botanic Garden of Indian Republic at Noida to study RET and other species
- Visit of Okhla Bird Sanctuary, Delhi and Butterfly Park, Gurugram (Haryana)
- Visit to a landfill site/industry
- Visit of rural/ urban (slum and other habitats) to under the environment and environmental issues, and prepare an eco-development plan for good living and environmental security
- Visit to plant nurseries to understand supply chain of plant species for promotion of urban biodiversity and bio-aesthetics
- Visit to natural hazards prone areas
- Visit to an institution engaged in biodiversity research and conservation (e.g., NBPGR, WWF, CSE, TERI, etc.), environmental pollution monitoring and control (e.g., CPCB), organic agriculture, climate-resilient agriculture and waste utilization (e.g., IARI, ICAR-Institute on Organic Agriculture), environment-friendly habitat (e.g. India Habitat Centre) and NGOs (e.g., Development Alternatives) actively engaged in environmental conservation and sustainable development initiatives
- Visit to green buildings

(B) Action-Oriented Field Visits

- Documentation of species in a Biodiversity register
- Visit any housing society and enquire about the environment-friendly measures adapted by the society. Based on your experience, suggest effective ways of involving community in

  environmental conservation (energy conservation, green space development, waste utilization, etc.) and disaster (if any) preparedness.
- Based on newspapers and magazine articles study, prepare an expanded note on any recent disaster that occurred in India or elsewhere. Explain its cause(s), effects and possible measures to manage it.
- Select any one newspaper and find out and report how it has covered a particular environmental issues or disaster (e.g., biodiversity discoveries and loss; climate change; air, rail or road accident, earthquake, drought, flood, etc.). Analyze the contents of its news coverage against time period (e.g., immediate report, two days later, one week/month later).
- Approach any government department/private organization/merchant or shopkeeper/person of civil society in your surroundings. Interact with them and observe their reaction response on environmental issues, and elicit their view towards environment and biodiversity conservation. Write a brief report on it.
- Know your ecological foot print and your neighbour too. Analyze the differences and suggest measures to minimize the foot print.

NOTE: The visits may be organized depending upon the availability of time and resources.

COURSE STRUCTURE
SEMESTER-I

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-I)

ES 417 DISASTER MANAGEMENT
Credit: (L-T-P): 3 (3-0-0)

OBJECTIVE

To explain disasters, their effects and approaches to manage them for the well-being of humans and environmental quality

OUTCOME

After completing the course, the learners would be able to develop a comprehensive view on disasters and disaster management, and the role of preparedness in reducing the effects of disasters.

CONTENTS

Disaster- Definition, classification, characteristics, causes, effects (social, economic and environmental), trends; Development vs. Disaster, Major disasters in India and global disasters

Natural Disasters- Cyclone and typhoon, lightening, tornado, avalanche, wildfire, volcanic erruption, drought, earthquake, tsunami, landslide, flood, heat and cold waves, cloud burst

Anthropogenic Disasters- Nuclear, chemical, biological, fire (building, coal, forest and oil), accidents (rail, road, air, marine and industrial), environmental decay (population explosion, occupational hazards, climate change, depletion of ozone layer, acidic precipitation, marine pollution), war and internal conflicts

Disaster Management- Concept, components (prevention, preparedness and mitigation), Disaster phases- Pre-disaster, during disaster and post-disaster; Initiatives for disaster management in India; Risk and vulnerability factors (e.g. poverty, displacement, etc.) associated with disasters

Disaster Preparedness- Concept, components, important measures- mapping, preparedness plan, land-use zoning; Essentials of effective disaster preparedness plan, Disaster preparedness for vulnerable groups, housing, infrastructure and livestock; Community-based disaster management plan; Disaster preparedness- Role of information, education, training and communication, role and responsibilities of government (central, state, district and local administration), armed forces, police, para-military forces, NDRF, SDRF, international agencies, NGOs, community-based organizations, community and media; Technologies for disaster preparedness

Disaster Mitigation- Concept, strategies and emerging trends, mitigation management

Disaster Response- Plan, logistic management, role of multiple stakeholders, psychological response, trauma, stress, rumour and panic management, health management indicators

Disaster and Development- Rehabilitation, reconstruction and recovery

Case Studies- Bhopal gas tragedy, Chernobyl disaster, Minamata disaster, Love canal disaster, Fukushima-Daiichi nuclear disaster, Kedarnath disaster and other latest disasters

SUGGESTED READINGS

Carter, W.N. 1992. *Disaster Management: A Disaster Manager's Handbook*. ADB Publication, Manila.
Cutter, S.L. 1999. *Environmental Risks and Hazards*. Prentice Hall of India Pvt. Ltd., New Delhi.

Gupta, H. 2003. *Disaster Management*, University Press, Hyderabad.
Pandey, M. 2014. *Disaster Management*, Wiley India P. Ltd., New Delhi.
Sahini, P. and Ariabandhu, M.N. 2003. *Disaster Risk Reduction in South Asia*. Prentice Hall of India Pvt. Ltd., New, Delhi.
Singh, S. and Singh, J. 2016. *Disaster Management*, Pravalika Publications, Allahabad.
Sinha, P.C. 1998. *Encyclopedia of Disaster Management*. Anmol Publications, New Delhi.
Viju, B. 2019. *Flood and Fury: Ecological Devastation in Western Ghats*, Ebury Press/Penguin.

COURSE STRUCTURE
SEMESTER-I

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-I)

ES 421 URBAN GREEN SPACE MANGEMENT
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To develop an understanding of importance of green spaces in urban ecosystems and techno-managerial issues associated with them

OUTCOME

The learners would be able to apply the concepts and practices of urban green space management for conserving environment and biodiversity, and promoting livelihood options in urban habitat

CONTENTS

The Urban Green Spaces: Introduction, The Urban habitats, Environmental issues in urbanizing world, urban greens (landscapes, urban forestry and biodiversity) – Uniqueness, national (Indian) and global perspective, Concept of smart cities and sustainable cities

Biodiversity in Urban Green Spaces: Species composition in green belts. avenue plantations, urban forest, vertical and horizontal gardens and amenity grasslands; Threats to urban biodiversity; Biodiversity conservation in urban landscapes; Biodiversity parks, Botanical gardens, Zoological parks and Aquaria, Green campuses and Green habitats

Management of Green Spaces and Aesthetic Landscapes: Urban landscape elements, Types of plantation and amenity grasslands, Tree/plant architecture and urban landscaping, Technical aspects of tree other plant species maintenance, soil and water conservation, control of pests and diseases

Green Space Planning: Integration of urban forestry and urban gardens in city planning, Social issues and institutional policy, Role of government, corporate, academia and research, financial institutions, NGOs, media, civil societies and citizens in urban green space development and management, case studies

SUGGESTED READINGS

Grey, G.W. and Denke, F.W. 1986. *Urban Forestry*, John Wiley and Sons, New York.
Miller, R.W. 1997. *Urban Forestry*: *Planning and Managing Urban Green Spaces*, 2nd Edition, Prentice-Hall India P. Ltd., New Delhi.

COURSE STRUCTURE

SEMESTER-I

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-I)

ES 423 OCEANOGRAPHY
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To impart knowledge about oceans, oceanic environment and resources

OUTCOME

The learners would able to understand the marine environment and air-water interface/ exchange

CONTENTS

Oceanography- Introduction, scope, oceanography in India; Marine environment- classification, open ocean, shallow marine and deep sea environment; Physiography of ocean-origin, evolution of ocean basins (continental and oceanic basins); Marine resources, Ecology of Banni area, Kutch Gujarat

Marine ecology – Physical, chemical and biological aspects of sea water, ocean current (circulation); Wave properties and motion, tidal currents and characteristics, air-water interface/exchange, gas solubility and circulation models; Marine organisms and productivity, beaches, coastal dunes, barrier islands, cliffed coast, delta coast line, estuaries and mangrove, lagoon, salt marsh, coral reef, marine sediments- clay minerals, biogenic silica, evaporates, nutrients in ocean; Oceanic carbon and global climate change

SUGGETED READINGS

Garrison, T. and Belment, C.A. 2009. *Essentials of Oceanography*, 5th Edn., Brooks/Cole, Cenagage Learning, USA.

Pinet, P.R. 2011. *Introduction to Oceanography*, Jones and Bartlett Learning, U.K.

COURSE STRUCTURE
SEMESTER-II

ES 402 EARTH RESOURCES AND PROCESSES
CREDIT: (L–T–P) : 3 (3-0-0)

OBJECTIVE

To impart fundamental knowledge related to geosphere and geographic and geological processes

OUTCOME

The basic knowledge of geosphere would benefit learners in understanding Earth resources and natural and human-induced hazards and disasters

CONTENTS

Origin of the Earth, Earth resources – Soil, water and mineral resources, geo-thermal energy; Primary geochemical differentiation and formation of core, mantle, crust, atmosphere and hydrosphere; Concept of minerals and rocks; Magma generation and formation of igneous, sedimentary and metamorphic rocks; Weathering including weathering reactions, erosion, transportation and deposition of Earth's materials (sediments) by running water, wind and glaciers; Formation of land forms; Plate tectonics - Sea floor spreading, mountain building, evolution of continents and structural deformation; Thermal, magnetic and gravitational fields of the Earth; Partitioning of elements during surficial geologic processes; Geochemical recycling of elements; Paleoclimate; Concepts of engineering geology

Distribution of water in Earth, hydrology and hydrogeology, major basins and groundwater provinces of India; Darcy's law and its validity, groundwater fluctuations, hydraulic conductivity, groundwater tracers, Ghyben-Herzberg relation between fresh-saline water; Effects of excessive exploitation of ground water

SUGGESTED READINGS

Hudson, T. 2011. *Living with Earth: An Introduction to Environmental Geology*; Pearson Education., Inc., New York.

Manahan, S. 2011. *Environmental Geology and Geochemistry: A Brief Introduction*, Chem Char Publisher, USA.

Merritts, D. 1998. *Environmental Geology: An Earth System Science Approach*, W H Freeman Publisher, New Delhi.

Montgomery, C. 2010. *Environmental Geology*, 9th Edition, McGraw-Hill Science Publisher, New Delhi.

Press, F. and Seiver, R. 2013. *Understanding Earth*, 4th Edition, W. H. Freeman Publisher, New Delhi.

Valdiya, K.S. 2012. *Environmental Geology*, McGraw-Hill Education (India) P. Ltd., New Delhi.

Website *- www.examrace.com*

COURSE STRUCTURE
SEMESTER-II

ES 406 SOIL SCIENCE
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To explain formation and properties of soil, factors causing soil erosion and land degradation, and soil conservation practices

OUTCOME

The learner would be able to understand value of soil and its fertility, and strive for conserving soil as a resource

CONTENTS

Soil Science: Definition and application; Soil forming rocks and minerals- classification; Soil formation- Factors of soil formation, soil forming processes, profile development, definition of soil, soil composition
Soil Properties: Physical properties-Soil separates and particle size distribution- soil texture and structure, bulk density, particle density, pore space, soil air, soil temperature, soil moisture, soil consistence, Significance of physical properties to plant growth; Chemical properties- Soil colloids, inorganic colloids, clay minerals, amorphous, ion exchange reactions, organic colloids, soil organic matter, decomposition-humus formation, significance on soil fertility, soil reaction; Biological properties of soil; nutrient availability
Soil Conservation: Soil erosion, derelict land and soil conservation; Desertification-definition, factors causing desertification, desertification control; Reclamation and restoration of degraded lands (case studies); Biofertilizers; Soil health card

SUGGESTED READINGS

Brady, N.C. and Ray, R.W. 2007. *The Nature and Properties of Soils*, Pearson Publications, New Delhi.
ISSC 2009. *Fundamentals of Soil Science*, Indian Society of Soil Science, New Delhi.
Jenny, H. 1941. *Factors of Soil Formation-A System of Quantitative Pedology*, McGraw- Hill book Company Inc., New York.
Tan, K.H. 2010. *Principles of Soil Chemistry*, CRC Press, New York.

COURSE STRUCTURE
SEMESTER-II

ES 408 ENVIRONMENTAL POLLUTION AND HUMAN HEALTH
CREDIT: (L-T-P): 4 (4-0-0)

OBJECTIVE

To provide in-depth knowledge of environmental pollution, its causes, consequences (with focus on human health) and control measures

OUTCOME

The learners would be able to utilize the knowledge for protection of self and society from pollution, and maintaining quality environment

CONTENTS

Air Pollution: Concept, Sources and Types of air pollutants- Natural and anthropogenic sources, Primary and secondary air pollutants, Criteria air pollutants; Sampling and monitoring of air pollutants (gaseous and particulates), period, frequency and duration of sampling; Principles and instruments for measurements of ambient air pollutants concentration, and stack emissions. Indian National ambient Air Quality Standards, Comprehensive environmental pollution index; Impact of air pollutants on human health, plants, animals and materials; Dispersion of air pollutants, Mixing depth (mixing ratio, saturation mixing ratio), lapse rates (saturated, adiabatic and environmental), wind roses; Control devices for particulate matters: Principle and working of setting chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator; Control of gaseous pollutants through adsorption, absorption, condensation and combustion including catalytic combustion; Indoor air pollution, Vehicular emissions and urban air quality, vehicular emissions in India, *e-riksha* and electric transport; Carbon sequestration and carbon credits

Noise Pollution: Sources, weighting networks, measurements of noise indices (L_{eq}, L_{10}, L_{90} L_{50}, L_{DN}, TNI); Noise dose and noise pollution standards; Impact of noise and vibrations on human health; Noise control and abatement measures: Active and Passive methods. Vibrations and their measurements

Water Pollution: Types and sources, ground water pollution, Eutrophication-concept, causes, effects and control measures; Impact of water pollution on humans, plants and animals; Water pollution: Vectors and diseases (e.g., Dengue); Indian standards for drinking water (IS: 10500:2012) and release of treated effluent in water bodies (IS: 2490:1981); Drinking water treatment-Coagulation and floccution, Sedimentation and Filtration, Disinfection and softening, Wastewater treatment- primary, secondary and advanced treatment methods. Common effluent treatment plant (CETP)

Marine Pollution: Sources and factors responsible for marine pollution, effects of marine pollution; major marine pollution episodes-Minnamata and Gulf war; Methods of abatement of marine pollution, coastal zone management

Soil Pollution: Sources (agricultural, industrial, mining and dumping) and factors causing soil pollution, Absorption of chemicals and toxic methods by soil; Industrial effluents and their interactions with soil components; Soil micro-organisms and their functions- degradation of pesticides and synthetic fertilizers;

Effect of soil pollution; Pesticides and diseases, Incidences of fluorosis, arseniosis and goitre in India; Control of soil pollution

Radioactive Pollution: Sources, radioactive decay, biological effects and health hazards associated with radiation, radiation exposure and radiation standards, radiation protection; Radioactive waste disposal, Control of radiation pollution

Thermal Pollution: Sources, Heat islands-causes and consequences, Chemical and biological effects of thermal pollution, Thermal pollution standard and control of thermal pollution; Thermal pollution from power plants and its control

SUGGESTED READINGS

Able, P.D. 2002. *Water Pollution Biology*, Taylor and Francis, London.

Gurjar, B. R., Ojha, C.S.P. and Molina, L.T. 2010. *Air Pollution-Health and Environmental Impact*, CRC Press, New York.

Khopkar, S.M. 2004. *Environmental Pollution Monitoring and Control*, New Age International P. Ltd., New Delhi.

Kiely, G. 2007. *Environmental Engineering*, Tata McGraw-Hill P. Ltd., New Delhi.

Masters, G. 1991. *Introduction to Environmental Engineering*, Prentice Hall India P. Ltd., New Delhi.

Masters, G.M. and Ela, W.P. 1992. *Introduction to Environmental Engineering and Science*, 3ed Edition, Pearson India Education Services P. Ltd., Noida, 692 p.

Palmer, E. 2010, *Water Pollution*, Apple Academics, Canada.

Peavy, H.S., Rowe, D.R., and Techobanoglous, G. 1985. *Environmental Engineering*, Tata McGraw Hill P. Publication Ltd., New Delhi.

Rao, C.S. 2007. *Environmental Pollution and Control*, New Age International P. Ltd., New Delhi.

Rao, C.S. 2011. *Environmental Pollution Control Engineering*, New Age International Publishers P. Ltd., Delhi.

Techbanoglous, G. Burton, F.K. and Stensel, H.D. 2010. *Wastewater Engineering*: *Treatment and Reuse* (Metcalf & Eddy, Inc.), Tata McGraw Hill P. Ltd., New Delhi.

COURSE STRUCTURE
SEMESTER-II

ES 410 CLIMATOLOGY AND GLOBAL CLIMATE CHANGE
CREDIT: (L–T–P) : 3 (3-0-0)

OBJECTIVE

To provide knowledge about climate, meteorological attributes, weather processes, global climatic conditions, and global climate change

OUTCOME

The learners would be able to understand weather and global climatic fluctuations and climate-related disasters

CONTENTS

Climatology-Introduction and scope; Weather and climate, Classification of climate - Koppen's and Thornthwaite's classification system; Meteorological attributes; Elements and control of climate; Earth's radiation balance, latitudinal and seasonal variations in insolation; Temperature, pressure, wind belts, humidity, cloud classification, formation and precipitation, water balance, spatial and temporal patterns of climate parameters; Air masses and fronts; SW and NE monsoon; Jet stream, Tropical and extra-tropical cyclone, El-Nino Southern Oscillation (ENSO), La–Nina, Quasi Biennial Oscillation (QBO); Global climate change-natural and anthropogenically-included, mechanism, global climate change and Indian climate, National Mission of India on Strategic knowledge for climate change

SUGGESTED READINGS

Ahrens, C. D. and Belmont, C.A. 2003. *Meteorology Today : An Introduction to Weather, Climate, and the Environment*, Brooks/Cole Cengage Learning Publication, Belmont, USA.

Barry, R. G. and Chorley, R. J. 2010. *Atmosphere, Weather and Climate*, 9th Edition, Rautledge Taylor and Francis Group, London.

Byers, H. R. 1974. *General Meteorology*, McGraw-Hill Inc.,New York.

Cole, F. 1980. *Introduction to Meteorology*, 2nd Edition, John Wiley and Sons, Inc. New Jersey.

Lutgens, F. K. and Tarbuck, E. J. 2004. *The Atmosphere : An Introduction to Meteorology*, Prentice-Hall Publication, New Jersey.

Mahapatra, R. and Jeevan, S.S. (eds.). 2018. *Climate Change Now: The Story of Carbon Colonization*, Centre for Science and Environment, New Delhi, 192 p.

Ramesh, M. 2018. *The Climate Solution*, Hachatte Book Publishing India P. Ltd., Gurugram, 325p.

COURSE STRUCTURE
SEMESTER-II

ES 412 HYDROLOGY
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To impart knowledge of hydrology, hydrobiology and conservation and management of water resource

OUTCOME

The learners would be able to appreciate value of water resource and attempt for its judicious use and conservation

CONTENTS

Definition and concept of surface and sub-surface hydrology and hydrogeology; Global distribution of water resources; Hydrological cycle; Hydrography; factors influencing surface water and characteristics of stream flow; Seasonal variations in stream flow, lake and wetland hydrology; Use and misuse of water; Aquaculture practices and water resource

Water Conservation: Watershed development, rainwater harvesting and ground water recharge, Genetic types of groundwater and residence time of groundwater; Geological control of groundwater; Vertical distribution of groundwater; Types of aquifers, springs and their classification, porosity and permeability, erosion and deposition of ground water; Darcy's law and its validity; Determination of hydraulic conductivity; Groundwater tracers. Environmental factors on Groundwater level fluctuations; Ghyben-Herzberg relationship between fresh-saline water; Groundwater exploration; Construction and design of different types of wells; Well completion and development; Hydrological development and management; Check dams; Management of groundwater recharge, and groundwater legislation; Impact of climate change on hydrological environment; National river conservation programme; *Namami Gange*; *Yamuna* action plan; *Ganga* action plan, National Water Mission; Environmental issues related to water resource projects- *Narmada* Dam, *Almatti* Dam, *Tehri* Dam , *Kaveri* and *Mahanadi* Dam; Hydropower projects in Jammu and Kashmir, Himachal Pradesh and North Eastern States of India

SUGGESTED READINGS

Chow, V., Maidment, D. and Mays, L. 2013. *Applied Hydrology*, McGraw-Hill Professional India Pvt. Ltd., New Delhi.

Deodhar, M.J. 2008. *Elementary Engineering Hydrology*, Pearson Education India, New Delhi.

Raghunath, H.M. 1985. *Hydrology*: *Principles, Analysis and Design*, John *Wiley* and Sons, Hoboken, New Jersey, USA.

Reddy, P.J.R. 2005. *A Textbook* of *Hydrology*, Laxmi Publications, New Delhi.

Todd D.K.1980. *Ground Water Hydrology*, John *Wiley* and Sons, Hoboken, New Jersey, USA

Website

https://www.aihydrology.org

http://nihroorkee.gov.in/

COURSE STRUCTURE
SEMESTER-II

ES 414 LABORATORY II
CREDIT: (L–T–P) : 4 (0–0–4)

OBJECTIVE

To provide opportunity to learners for hands-on practice on environment-related knowledge inputs as provided to them in courses during classroom learning in the second semester

OUTCOME

To learners would be able to appreciate and realize the importance of practice for theory courses-related inputs, and develop practical skills of analyzing environment and environmental factors

CONTENTS

S. No.	Experiment
1.	To determine relative humidity in ambient air using hygrometer
2.	To determine on-site soil temperature and humidity at different depths of soil
3.	To determine texture of soil using Jar test method
4.	To determine moisture content and water holding capacity in given soil samples
5.	To determine organic carbon and organic matter in given soil samples
6.	To determine the on-site bulk density and organic carbon stock of soil
7.	To determine total Kjeldahl nitrogen in given soil samples
8.	To determine available phosphorus in given soil samples
9.	To determine on-site basal respiration ($C0_2$ emission) in soil
10.	To determine total carbon in different components of selected plant species
11.	To study carbon sequestration by selected tree species
12.	To estimate carbon footprint using carbon footprint calculator
13.	To determine minimum size of quadrat for the study of plant biodiversity of the sample site
14.	To determine Importance Value Index (IVI) of (herbaceous) species of the site sample
15.	To prepare biological spectrum of the sample site using Raunkiar's life form classification
16.	To study indices of species diversity and similarity in the sample site
17.	To determine the level of noise at selected sites
18.	To isolate plant growth promoting rhizobacteria/rhizobia from soil
19.	To isolate siderophore producing bacteria from soil
20.	To perform negative staining of bacteria
21.	To determine LD_{50} value of given toxicant against bacteria
22.	To study treatment of coloured wastewater using microbes (Bacteria and Fungi)

SUGGESTED READINGS

Aneja, K.R. 2018. *Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology*, 5th Edition, New Age International (P.) Ltd. Publishers, New Delhi

APHA.1997. *Standard Methods for Examination of Water and Wastewater*, 21st Edition, American Public Health Association, American Water Works Association and Water Pollution Control Foundation, Washington, D.C.

Jackson, M.L. 1998. *Soil Chemical Analysis*, Revised Edition, Prentice Hall, London.

Kapur, P. and Govil, S.R. 2004. *Experimental Plant Ecology*, CBS Publishers and Distributors, New Delhi, 154 p.

Piper, C.S. 1995. *Soil and Plant Analysis*, Revised Edition, University of Adelaide, Australia.

Trivedi, R.K. Goel, R.K. and Trisal, C.L. 1998. *Practical Methods in Ecology and Environmental Science*, Revised Edition, Environmental Publications, Karad.

COURSE STRUCTURE
SEMESTER-II

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-II)

ES 416 ENVIRONMENTAL PLANNING, POLICY AND LEGISLATION
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To develop broad understanding of institutional aspect of environmental conservation and management

OUTCOME

To learners would be able to utilize scientific and technological skills, and institutional understanding in policy planning and decision-making to achieve environmental security, biodiversity conservation and sustainable development

CONTENTS

Environmental Planning: Definition, need of policy, law and ethics for environmental conservation and sustainable use of resources, policy frameworks for environment in India; Environmental economics-Concept, significance for environmental planning, valuation methods and case studies, role of NGOs in environmental management

Environmental Ethics: Concept, importance for quality environment and living, ethical theories (homocentric, biocentric and ecocentric), animal rights, deep ecology, land ethics and ecofeminism

International Environmental Institutions: UNEP, IUCN, WWF, UNESCO (MAB, IGBP), IUBS (DIVERSITAS), IPCC, WRI, World Commission on Sustainable Development

International Environmental Conventions and Agreements: Stockholm Declaration, Ramsar Convention, Vienna Convention and Montreal Protocol, Basel convention, CITES, Convention to Combat Desertification (CCD), Earth Summit-1992, CBD, Earth Summit at Johannesberg 2002, $Rio^{+}20$, GEF, Conventions related to climate change (UNFCCC, Kyoto Protocol, CoPs, CDM, Paris Agreement 2015), UN Summit on Millennium Development Goals 2000 and Sustainable Development Goals 2015, Copenhagen Summit 2009

Environmental Policies in India- Constitution provisions-Article 48 A and Article 51 A, National Forest Policy 1988, National Water Policy 2002, National Landuse Policy 2019., National Environment Policy 2006, National action Plan on Climate Change 2009, National Green Tribunal Act 2010, National Electric Mobility Mission Plan-2020, 2013

Environmental Legislations in India:

(a) Related to Forest, Wildlife and Biodiversity-Wildlife Protection Act 1972, amendments 1992, 2013, Forest Conservation Act 1980, Indian Forest Act (revised) 1982, Biological Diversity Act 2002 and Rules 2004, Protection of Plant Varieties and Farmers Rights Act 2002

(b) Related to Water, Air and Environment- Air (Prevention and Control of Pollution) Act 1981 amended 1987 and Rules 1982, Environment (Protection) Act 1986 and Rules 1986, Noise Pollution

(Regulation and Control) Rules 2000 , Coastal Regulation Zones (CRZ) Act 1991 amended from time to time, The Public Liability Insurance Act 1991 and Rules 1991

(c) Related to Wastes- The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules 2000, The Hazardous and other Wastes (Management and Transboundary Movement) Rules 2016, The Solid Waste Management Rules 2016, The Plastic Waste Management Rules 2016, The Bio-medical Waste Management Rules 2016, The e-Waste Management Rules 2016, The Construction and Demolition Waste Management Rules 2016

(d) Related to Vehicular Emission-Motor Vehicle Act 1988, The Batteries (Management and Handling) Rules 2010 and amendments

Environmental Management Standards- ISO 14000 series, Eco-labeling (ecomark) schemes

SUGGESTED READINGS

Bhat, S. 2010. *Natural Resources Conservation Law*, Sage Publishers, New Delhi.

Desai, B. 2010. *Multilateral Environmental Agreements: Legal Status of the Secretariats*, Cambridge University Press, Cambridge.

Diwan, S. and Rosencranz, A. 2005. *Environmental Law and Policy in India*, Oxford University Press, New Delhi.

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Ganesamurthy, V.S.2011. *Environmental Status and Policy in India*, New Century Publications, New Delhi.

Jamieson, D. 2008. *Ethics and the Environment: An Introduction*, Cambridge University Press, Cambridge.

Keshav, K. 2017. *Law and Environment*, Singhal Law Publication, Delhi, 404 p.

Krishnamurthy, B. 2017. *Environmental Management, Text and Case Studies* 3ed Edition., PHI Learning P. Ltd., Delhi, 300 p.

Leelakrishnan, P. and Wadhwa, B. 2008. *Environmental Law in India*, Sage Publishers, New Delhi.

Ortolano L. 1984. *Environmental Planning and Decision Making*, John Wiley and Sons, New York.

Sankar, R.N. 2015. *Environmental Management*, Oxford University Press, New Delhi, 588 p.

Selman, P. 1992. *Environmental Planning*, Paul Chapman Publishing Ltd., London, 191p.

Sulphey, M.M. and Safeer, M.M. 2017. *Introduction to Environment Management*, PHI Learning P.Ltd., Delhi, 408 p.

WCED. 1987. *Our Common Future*, (World Commission on Environment and Sustainable Development, WCED), Oxford University Press, Oxford.

COURSE STRUCTURE
SEMESTER-II

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-II)

ES 418 MICROBIAL ECOLOGY
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To impart knowledge of microbes, microbial ecology and microbes-environment interactions

OUTCOME

Application of knowledge of microbes and microbial ecology in environmental conservation and healthy living

CONTENTS

An overview of microbial life and its importance in environment, Microbial structure and function with special emphasis on bacteria and Archea, Evolution and microbial phylogenetic diversity, Microbial nutrition and metabolism with emphasis on microbial metabolic diversity, Environmental factors affecting microbial growth and microbial adaptions to extreme environments (like arctic regions and hot springs); Methods in microbial ecology including introduction to microbial genomics, Microbial habitats (air, soil, sub-surface, fresh water, marine and deep sea), Introduction to geo-microbiology; Natural microbial communities with emphasis on biofilms, Microbial biogeochemical process of nutrient cycling and biodegradation, Microbial interactions: microbe-microbe interactions; Plants and animals as microbial habitats and human microbiome; Applying microbes in wastewater treatment and solid waste management, Industrial applications of microbes including products for pharmaceutical, food and beverage industry and biofuels; Molecular biotechnological applications including genetic engineering for production of vaccine, diagnostics, biopesticides and transgenic plants, Microbial disease ecology and public health, Transmission of microbial diseases through the environment

SUGGESTED READINGS

Aneja, K.R. et al. 2010. *A Text Book of Basic and Applied Microbiology*, New Age International Publishers, New Delhi.

Black, J.G. 2005. *Microbiology-Principles and Explorations*, 6th Edition, John Wiley and Sons, New York.

Mc Arthur, J. 2006. *Microbial Ecology: An Evolutionary Approach*, Elsevier Scientific Publisher, New York.

Odum, E.P. 1996. *Fundamentals of Ecology*. Indian Reprint, Natraj Publishers, Dehradun.

Prescott, L.M. Harley, J.P. and Klein, D.A. 2003. *Microbiology*, 5th Edition, Mc Graw Hill, Publication, New York.

Rana, S.V.S. 2005. *Essentials of Ecology and Environmental Sciences*, Prentice-Hall of India Private Limited, New Delhi.

COURSE STRUCTURE
SEMESTER-II

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-II)

ES 420 AGROECOLOGY AND AGROFORESTRY
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To explain fundamentals of agroecology and agroforestry, and role of agroforestry in environmental conservation

OUTCOME

The knowledge of agroecology and agroforestry could be applied for promoting conservation agriculture and sustainable landuse development

CONTENTS

Agricultural ecosystems; Agricultural practices; Green revolution-environmental implications; Ecology of shifting agriculture; Sustainable agriculture, organic farming, eco-farming, dry-land farming, zero-tillage, bio-fertilizers, plant growth promoting bacteria; Agro-biodiversity and sustainability

Environmental impacts of modern agriculture-Soils and agriculture, irrigation practices, water logging and secondary salinization; agrochemicals, pesticide residues

Crop Protection-biodegradable and non-biodegradable pesticides; pesticide resistance; Biological and ecological pest control, integrated pest management, pesticide safety and microbial insecticides; Biosafety issues in agriculture; Role of microbes in agriculture-beneficial root-microbial interactions.

Traditional and modern agroforestry systems of India; Agroforestry for soil and water conservation, carbon sequestration and agro-biodiversity enhancement, Future scope of Agroforestry for environmental and food security, case studies on agroforestry

SUGGESTED READINGS

Gliesman, S.R. 2002. *Agroecosystem Sustainabilty: Developing Practical Strategies*, CRC Press, New York.

Kumar, B.M. and Nair, P.K.R. (Eds.) 2006. *Tropical Homegardens: A Time-tested Example of Sustainable Agroforestry, Series: Advances in Agrroforestry*, Vol.3, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Lynggaard, K. 2006. *The Common Agricultural Policy and Organic Farming: An Institutional Perspective on Continuity and Change*, CAB International, UK.

Newton, P.C.D., Carran R.A., Edwards, G.R. and Niklaus, P.A. 2007. *Agroecosystems in a Changing Climate. Advances in Agroecology* Vol.12, CRC Press New York.

Young, A. 1997. *Agroforestry for Soil Management*, CAB International, UK.

COURSE STRUCTURE
SEMESTER-II

GENERIC ELECTIVE-I (GE-I)

FT 312 FOOD PROCESSING WASTE MANAGEMENT
CREDIT: (L-T-P) 3 (3-0-0)

OBJECTIVE

To impart knowledge of wastes and by-products of food processing, their effects on the quality of environment, and measures to minimize the production of wastes and food processing waste management

OUTCOME

The learners would be able to utilize knowledge of waste production and its management in food processing

CONTENTS

Food Industry Wastes and Environmental Pollution: Characterization of food industry effluents, Physical and chemical parameters, Oxygen demands and their interrelationships; Residues (solids), fats, oils and grease; Forms of nitrogen, sulphur and phosphorus, anions and cations, surfactants, colour, odor, taste and toxicity; Unit concept of treatment of food industry effluents, screening, sedimentation /floatation as pre-and primary reactants

Food Industry By-products and their Utilization: Characterization and utilization of by-products from cereals, pulses, oilseeds, fruits, vegetables, plantation crops, fermented foods, milk, fish, meat, egg and poultry processing industries

Biological Oxidation: Objectives, Organisms involved, Reactions, Oxygen requirements, Aeration device systems: Lagoon, Activated sludge process, Oxidation ditch, Rotating biological contactor-variations and advanced modifications

Waste Water Management: Wastewater treatment systems, Physical separations, Micro-strainers, Filters, Ultra filtration and reverse osmosis; Physico-chemical separations- activated carbon adsorption, ion-exchange, electro dialysis and magnetic separation; Chemical oxidation and treatment-coagulation and flocculation, disinfection; Handling disposal of sludge

Standards and Acts: Food industry wastes, Food waste treatment-ISO 14001 standards, Standards for emission or discharge of environmental pollutants from food processing industries according to Environment (Protection) Act 1986, Elements of importance in the efficient management of food processing wastes

SUGGESTED READINGS

Lawrence K. W., Howard, H. Y. and Yapijakis, C. 2005.*Waste Treatment in the Food Processing Industry*, CRC Press, New York.

Loannis, P. and Arvanitoyannis, S. 2008. *Waste Management for the Food Industries*, Elsevier Publishers, New York.

Metcalf, P. and Eddy, L. 2013. *Wastewater Engineering Treatment and Resource Recovery*, 5th Edition, McGraw Hill Publication, New York.

Rao M.N. and A.K. Datta. 2008. *Waste Water Treatment*, Oxford and IBH Publishing Co Pvt. Ltd, New Delhi.

Wang, C. and Taylor, Lo H. 2006. *Waste Treatment in the Food Processing Industry*, CRC Press, New York.

COURSE STRUCTURE
SEMESTER-II

GENERIC ELECTIVE-I (GE-I)

UP 102 SETTLEMENT PLANNING
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To impart knowledge about human settlement planning, growth and development in urban ecosystem

OUTCOME

The basic knowledge of human settlement planning in urban ecosystem would facilitate learners to develop sustainable eco-friendly urban human settlement and sustainable cities

CONTENTS

Basic Concepts: National and international concepts on human settlement planning and urban development with emphasis on Asian cities; Relevance to Indian context; Smart city concept

Urban Growth and System of Cities: Growth of metropolitan and mega-cities: Scale, complexity and its impact on national development; Convergence and divergence in urban growth; Inner City: Issues and problems; Approach to Development: Urban re-development and renewal, goals, objectives, costs and benefits; Core, fringe and periphery: Core and fringe; core and periphery; peri-urban development and its dynamics

Mega Urban Regions: Emergence of mega regions in India, differences between mega and metro regions, complexities in planning for mega regions

Metropolitan Cities: Growth in trends, characteristics, problems and socio-economic and political issues in India vis-à-vis Asia; Primacy, polarization and processes of metropolitan growth in India; Sectoral diversity, growth and unintended growth in metropolitan areas; regional specialization of cities and multi-nuclei development and functional inter-linkages; Metropolitan Growth Control: Dispersion of population, planning for new towns- types, design criteria; development process and issues; New town approach in India: Small-and medium town development

Urban Policies, Projects and Programmes: Their funding, impact on metro and mega-city development, 73rd and 74th constitutional amendments and their impact

Urban Renewal and Regeneration: JNUURM. Heritage Policy; Local area plans (heritage and slum upgradation, local economic policy)

SUGGESTED READINGS

Challen, P. *Migration in the 21st century: How Will Globalization and Climate Change Affect Human Migration and Settlement? (Investigating Human Migration and Settlement),* Crabtree Publishing Company, Ontario.

Marcuse, P. and Kempen R.V., *Globalizing Cities: A New Spatial Order*, Wiley-Blackwell, New Jersey.

Shaikh J. *Residential Planning and Neighbourhood Models, Mega-city Karachi: Urban Forces and Patterns for the Mushroom Growth of Concrete Jungle in the Mega-Metropolitan city Karachi*, VDM Verlag, Riga.

UNHSP.2009. *Planning Sustainable Cities: Global Report on Human Settlements 2009:* - Abridged Edition, United Nations Human Settlements Programme, Earthscan/UN Habitat, London.

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COURSE STRUCTURE
SEMESTER-III

ES 501 ENVIRONMENTAL TOXICOLOGY AND BIOREMEDIATION
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To impart knowledge about environmental toxicology and applications of microbes and macro plant species in controlling pollution

OUTCOME

The learners would be able to develop technological skills of pollution control and apply them in real-life situations considering the toxicological aspects

CONTENTS

Principles in Toxicology; Definition of Xenobiotics; Animal management in toxicological evaluation, margin of safety, therapeutic index; Routes of exposure of toxicants, Absorption and distribution Animal toxicity test; Statistical concept of LD_{50}; Threshold limit value, Concept of bioassay, Acute and chromic toxicity; Dose effect and dose response relationship; Biological and chemical factors that influence toxicity; Biotransformation(excreation mechanism and excretion of toxic agents) and bioaccumulation; Ecosystem influence on fate and transport of toxicants, Concept of green chemistry; Classification and toxicity of pesticides, heavy metals, metalloids, Votalile organic compounds (VOCs), Endocrine disrupting compounds (EDCs) and Persistent organic pollutants (POPs); Carcinogens in the air; Occupational health hazards

Aquatic Toxicity Tests: Response of planktons to toxicants; EC_{49}; Photosynthetic bacteria; Information management system in eco-toxicology

Bioremediation: Concept and applications of bioremediation in controlling pollution problems, *e.g.*, sludge, sewage water, industrial effluents, heavy metals, radioactive substances, oil spillage and synthetic dyes; Role of microbes in treatment of domestic and industrial waste water; Metagenomics: Concept and applications in bioremediation

Phytoremediation: Definition, types, mechanism (related case studies); Abatement of pollution using macro plant species

SUGGESTED READINGS

Butler, G.C. 1978. *Principles of Ecotoxicology*, (SCOPE), John Wiley and Sons P. Ltd, Hoboken, USA.

Connell, D., Lam, P., Richardson, B. and Wu, R. 1999. *An Introduction to Ecotoxicology*, Blackwells, Hoboken, New Jersey.

Landis, W.G. and yu, M.H. 2003. *Introduction to Environmental Toxicology*, Lewis Publishers, Florida, USA.

Newman, M.C. and Unger, M.A. 2003. *Fundamentals of Ecotoxicology*, Lewis Publishers, Florida

Rapport,D., Costanza, R,R., Epstein, P.R., Gaudet, C and Levins, R. 1998. *Ecosystem Health*, Blackwells Scientific Publisher, New York.

Walker, C.H., Hopkin, S.P., Sibly, R.M. and Peakall, D.B. 2008. *Principles of Toxicology*, Taylor and Francis, New York.

Wright, D.A. and Welbourn, P. 2002. *Environmental Toxicology*, Cambridge University Press, Cambridge.
Yu, M.H. 2004. *Environmental Toxicology*: *Biological and Health Effects of Pollutants*, CRC Press, New York.

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https://www.epa.gov/2.
https://setac.org
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COURSE STRUCTURE
SEMESTER-III

ES- 503 BIODIVERSITY AND ENVIRONMENTAL CONSERVATION
CREDIT: (L-T-P): 4 (4-0-0)

OBJECTIVE

To familiarize learners about biological diversity in broader perspective as a basis for environmental suitability and sustainable human living on the Earth

OUTCOME

The learners would be able to develop understanding of biodiversity as a resource, causes of its loss, significance for conservation and initiatives for conservation of environment vis-à-vis biodiversity at a national (India) and global level

CONTENTS

Biodiversity- Concept, types, patterns (spatial and temporal), biodiversity for environmental and food security; National (Indian) and global status of biodiversity (natural flora including mangroves and corals, fauna and microbes; domesticated plants and animals, agriculturally-important microbes); Drivers of biodiversity (climate, geological and humans), Monitoring of biodiversity; threats to biodiversity
Biodiversity Hotspots- Definition and basis of identification, global occurrence; Characteristic flora and fauna of Indian biodiversity hotspots; Bio-geographic regions and agro-climatic zones of India, Endemic species, IUCN species categories of Red list, threatened and endangered species of plants and animals in India; Wildlife distribution in India and values of wildlife
Species Invasion- Concept, importance, theories of invasion, major invasive species; Invasive species, environment and native biodiversity, regulation of introduction of invasive species and their management
Biodiversity and People- Socio-cultural value of biodiversity; Biodiversity in rural and urban landscape; The conservationist people, green consumerism, Biodiversity in different religions, Indigenous knowledge (traditional ecological knowledge) and biodiversity; Human-wildlife conflict; and wildlife crime; Concept of gene pool, biopiracy, IPRs and bio-prospecting
Biodiversity and Environmental Conservation-Valuation of biodiversity for conservation planning; History of conservation, conservation ethics, deep ecology; World conservation strategy; Contemporary global biodiversity challenges (The 6th Mass extinction, The Red list and a catastrophic decline): Restoration ecology as a tool for conservation; Traditional conservation mechanisms (religious tree and animal, sacred landscape and sacred grove), Indigenous knowledge and people's biodiversity register; Conservation movements- *Bishnoi* movement, *Chippko*, *Appiko*, *Gandhamardhan*, *Narmada* and Silent valley movements
Conservation in Practice- *In-situ* conservation practices-protected area network (Preservation plot, National park, Wildlife Sanctuary, Conservation reserve, Community reserve, On-farm conservation and Biosphere reserve); *ex-situ* conservation practices-Botanic garden, homestead garden, Arboratum, Bamboosetum, fernaria, Cacteria, herbarium, Zoo, Aquarium, and *in-vitro* conservation practices-gene bank, cryobank (pollen and spore bank) and DNA library; International initiatives for environmental protection

Conservation of wetlands, Ramsar sites in India; Species-specific wildlife conservation in India- Project Tiger, Project Elephant, Crocodile conservation, Sea turtle Project, Project rhinoceros; Eco- development and eco-tourism as an instrument for conservation; Biotechnology and biodiversity

(GMOs, Biopesticides, Bioremediation, Phytoremediation, Micro-propagation), Eco-friendly measures to mitigate impacts of linear infrastructure on wildlife

Institutions and Conventions for Conservation - IUCN, WWF, UNEP, IUBS, FAO, CITES, TRAFFIC, CBD, TRIPS, Green Peace, International Whaling Commission, IUCN Species Survival Commission, Ramsar Convention, Bonn Convention on (Migratory species) of Wild Animals, UN law of the Seas, International treaty on plant genetic resources for food and agriculture, Global Biodiversity Information Facility

Institution, Policy and Law for Conservation in India – Role of Government Institutions in Environmental Policies, Ministry of Environment Forest and Climate Change (GOI), National Biodiversity Authority, Protection of Plant Varieties and Farmers' Rights Authority, Wildlife Board, Wildlife Institute of India, Wildlife Crime Control Bureau; National Forest Policy 1988, National Environment Policy 2006; Wildlife (Protection) Act, 1972, Wildlife (Protection) Rules, 1995, The Wildlife (Protection)Amendment Act, 2002, 2013, Forest(Conservation) Act,1980, Biodiversity Act, 2002, Biodiversity Rules 2004, Protection of Plant Varieties and Farmers' Rights Act 2001, 2007; Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; National Biodiversity Action Plan

SUGGESTED READINGS

Anathkrishnan, T. N.1982. *Bioresources Ecology*. Oxford and IBH Publishing Co. P. Ltd., New Delhi.

Benson, E. E, 1999. *Plant Conservation Biotechnology*, Taylor and Francis, London.

Dwivedi, A.P. 2008. *Managing Wildlife in India*, Sai Publications, Bhopal.

Gadgil, M. and Rao, P.R.S. 1988. *Nurturing Biodiversity: An Indian Agenda*, Centre for Environmental Education, Ahmadabad, 163p.

Gibbs, J.B., Hunter M.L., and Sterling E.J. 2008. *Problem-solving in Conservation Biology and Wildlife Management: Exercises for Class, Field and Laboratory*. Blackwell Publications, New York.

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Hambler, C. 2004. *Conservation*, Cambridge University Press, Cambridge.

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Krishnamurthy, K.V. 2004. *An Advanced Textbook on Biodiversity Principles and Practices*. Oxford and IBH Publishers, New Delhi.

Loreau, M. Naeem S. and Inchausti, P. 2002. *Biodiversity and Ecosystem Functioning: Synthesis and Perspectives*, Oxford University Press, Oxford.

Magurram, A.E. 2003. *Ecological Diversity and its Measurement*, Blackwell Publications, New York.

Maiti, P.K. and Maiti, P. 2017. *Biodiversity: Perception, Peril and Preservation*, PHI Learning P. Ltd., New Delhi.

MoEFCC. 2018. *State of Environment Report: India 2015*, Ministry of Environment, Forest and Climate Change (Govt. of India), New Delhi, 273 p.

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Pullin, A.S. 2002. *Conservation Biology*. Cambridge University Press, Cambridge.

Ramakrishnan, P.S. 2014. *Premier on Characterizing Biodiversity*, National Book Trust-India, New Delhi, 66p.

Ramakrishnan, P.S. 2015. *The Cultural Cradles of Biodiversity*, National Book Trust-India, New Delhi, 230p.

Sawarkar, V. B. 2005. *Planning Wildlife Management in Protected Areas and anaged Landscapes*, Wildlife Institute of India and Natraj Publishers, Dehradun.

Sharma, A.K., Ray, D., and Ghosh, S.N. (eds.). 2012. *Biological Diversity: Origin, Evolution and Conservation*, Viva Books, New Delhi.

WII. 2016. *Eco-friendly Measures to Mitigate Impacts of Linear Infrastructure on Wildlife*, Wildlife Institute of India, Dehradun, 148p.

COURSE STRUCTURE
SEMESTER-III

ES 505 REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM
CREDIT: (L–T–P): 3 (3-0-0)

OBJECTIVE

To provide fundamental knowledge of remote sensing and GIS, and their application in environmental monitoring, forecasting and resource management

OUTCOME

The learners would be able to apply the knowledge so acquired for environment and natural resource management, and urban planning

CONTENTS

Introduction to Remote Sensing – Definition, principles, history and elements of remote sensing; Electromagnetic radiation and its sources, EMR spectrum, radiation laws; Atmospheric windows, Interaction of EMR with atmosphere and Earth surface, Spectral signatures; Application of remote sensing, Advantages and disadvantages of remote sensing, supervised and unsupervised classifications, ground control points (GCP)

Remote Sensing Systems (Active and Passive; Imagining and Non-imaging), Orbit and platforms of Earth observation, sensors and scanners; Types of Resolution – spatial, spectral, radiometric, temporal; Photogrammetry, Elements of image interpretation, Ground truth collection, Global Positioning System (GPS)

Introduction to Geographic Information System (GIS) – Definition, attributes, functions and process; Remote sensing and GIS applications in land cover/land use planning and management, urban sprawling, vegetation study, forestry, natural resources, waste management and climate change

Remote sensing and GIS software use in solving environmental problems including groundwater exploration, Rainwater harvesting, Biomass analysis; Applications of Remote sensing and GIS in disaster management such as, early warning of Tsunami, Earthquake, Snowfall, Forest fire, Landslide, and subsidence

SUGGESTED READINGS

Bhatta, B. 2011. *Remote Sensing and GIS*. Oxford University Press, 2nd Edition, New Delhi.

Jensen, J.R. 2007. *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd Edition, Prentice Hall, New Jersey.

Joseph, G. 2005. *Fundamentals of Remote Sensing*, University Press, Hyderabad.

Lillesand, T.M., Kiefer, R.W. and Chapman, J.W. 2007. *Remote Sensing and Image Interpretation*, 5th Edition, John Wiley and Sons, Inc. New Jersey.

Richards, J.A. and Jia, X. 2006. *Remote Sensing Digital Image Analysis: An Introduction*, 4th Edition, Springer Verlag, Berlin.

Website **-** *www.nptel.ac.in/courses/105108077/*

COURSE STRUCTURE

SEMESTER-III

ES 507 WASTE MANAGEMENT
CREDIT: (L–T–P) : 3 (3-0-0)

OBJECTIVE

To sensitize learners about different wastes, waste-specific environmental concerns and waste management

OUTCOME

The knowledge so obtained could be utilized for waste utilization and zero waste living

CONTENTS

Waste - Definition and categories; Solid waste - Definition, types, sources, characteristics, proximate and ultimate analysis of solid waste and impact on environmental health; Waste generation rates and scenario, Urbanization and waste generation

Waste Management - Concepts of waste reduction, 3R and 5R concept, recycling and reuse; Solid waste collection and transportation - Waste segregation, container systems, transfer stations and transportation, Decentralized solid waste management system, *Swachha Bharat Abhiyan*, Composite waste management index

Waste Processing and Treatment Technologies - Mechanical and thermal volume reduction; Electrical energy from solid waste – Fuel pellets and Refuse Derived Fuel (RDF), Thermal Techniques – Incineration, Pyrolysis and Gasification; Chemical techniques – Biomethanation, Bioethanol and Biodiesel; Energy and resource recovery from waste - Composting, Vermi-composting, Incineration of solid wastes, Waste disposal in landfills: Site selection, design, and operation of sanitary landfills, secure landfills and landfill bioreactors, leachate and landfill gas management, landfill closure and post-closure environmental monitoring; landfill remediation, case studies

Hazardous Wastes - Definition, sources and characteristics; Hazardous waste treatment methods – Neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal; Hazardous waste management and disposal; Legislation on management and handling of municipal solid wastes and hazardous wastes

Neo-wastes and their Management

e-waste - Classification, sources, methods of handling and disposal

Fly ash - Sources, composition and utilization

Plastic waste – Sources, consequences and management

SUGGESTED READINGS

Buckingham, P.L. and Evans, J.C. 2010. *Hazardous Waste Management*, Waveland Press Inc., USA.

Cheremisinoff, N.P. 2002. *Handbook of Solid Waste Management and Waste Minimization Technologies*, Elsevier Scientific Publishers, Woburn.

Khan, I. H. and Ahsan, N. 2003. *Textbook of Solid Wastes Management*, CBS Publishers, New Delhi.
Masters, G.M. 2008. *Introduction to Environmental Engineering and Science*, Prentice Hall, India P. Ltd. New Delhi.
Tchobanoglous, G. 2002. *Handbook of Solid Waste Management*, McGraw-Hill, New York.

Website *– www.swayam.gov.in/*

COURSE STRUCTURE
SEMESTER-III

ES 509 ENVIRONMENTAL IMPACT ASSESMENT AND SUSTAINABLE DEVELOPMENT
CREDIT: (L-T-P): 3 (3-0-0)

OBJECTIVE

To explain the concepts and tools of environment management and holistic inter-generational development

OUTCOME

The learners would be able to utilize the environmental management tools and holistic inter- generational development concept for achieving environmental security and sustainable society

CONTENTS

Environmental Impact Assessment (EIA): Background (Linkage between environment and development), Definition, Aims and objective, Development of EIA in India, Core values and guiding principles; Environmental components of EIA (air, water, noise, land and biological); Main participants of EIA-Project proponent, Consultant, State Pollution Control Board, Public and Impact assessment agency; EIA process:Preliminary steps-screening and scoping identification, forcasting (prediction), monitoring (evaluation/auditing of environmental impacts) and preparation of environmental impact statement-EIS environmental management plan-EMP (mitigation), and communication (site-specific, followed by presentation to State/Central Government (MoEFCC) for environmental clearance); EIA methodologies and guidelines; Life-cycle analysis, Cost-benefit analysis, Benefits and improving effectiveness of EIA process, EIA Notification of India 2006 and amendments from time to time; Guidelines for environmental audit; Environmental planning as a part of EIA and environmental audit; EIA of selected development projects (case study)-Hydro-power project, thermal project, Mining project, Infrastructure project

Sustainable Development (SD): Causes of unsustainablity, concept of SD, International programmes on SD-World Commission on Environment and Development (WCED), UNCED-Agenda 21, World Summit on SD (WSSD); Global sustainability, threats to SD; Guiding principles of SD, Sustainability indicators, Environmental sustainability index-strengths and weaknesses; Sustainable Development Goals; Relationship of EIA to SD; Sustainable development in India, Sustainable habitat-Green building, GRIHA rating norms

SUGGESTED READINGS

Bartelmus, P. 1994. *Environment, Growth and Development: The Concepts and Strategies of Sustainability*, Routledge, Taylor and Francis Group, Oxfordshire, U.K.

Cohen, J. E. 1995. *How Many People can the Earth Support*?, Norton & Co., New York.

Eccleston, H. 2011. *Environmental Impact Assessment: A Guide to Best Professional Practices*. CRC Press, New York.

Glasson, J., Therievel, R. and Chadwic, A. 2005. *Introduction to Environmental Impact Assessment*, 3rd Edition, Routledge, Taylor and Francis Group, Oxfordshire, U.K.

Lawrence D. P. 2003. *Environmental Impact Assessment: Practical Solution to Recurrent Problems*, John Wiley and Sons Inc. Publishers, New York.

Morris, P. and Therivel, R. 2009. *Methods of Environmental Impact Assessment*. Routledge (Francis & Taylor Group), Oxfordshire, U.K.

Reid, D. 1995. *Sustainable Development: An Introductory Guide*. Earthscan Publication Ltd., London.

Rogers, P., Jalal, K.F. and Boyd J. D. 2007. *Introduction to Sustainable Development*, Earthscan Publication Ltd., London.

Wathern, P. 1988. *Environmental Impact Assessment-Theory and Practice*, Routledge, Taylor and Francis Group, Oxfordshire, U.K.

WCED. 1987. *Our Common Future*, (World Commission on Environmental and Sustainable Development, WCED), Oxford University Press, Oxford.

COURSE STRUCTURE
SEMESTER-III

ES 511 ADVANCED ANALYTICAL TECHNIQUES FOR ENVIRONMENTAL MONITORING

CREDIT: (L-T-P) 4 (4-0-0)

OBJECTIVE

To explain theoretical knowledge of advanced analytical techniques useful for monitoring the quality of environment

OUTCOME

The learners will acquire background knowledge of advanced analytical techniques for conducting experiments in the laboratory classes

CONTENTS

Physico-chemical methods for water and soil analysis: Physico-chemical parameters – Definition and determination of electrical conductivity, pH, DO, COD, BOD; Sampling and Sample preparation; Sampling of ambient air, water and soil; Sampling equipments; Preparation of sample for metal analysis in water, ambient air and soil; Analysis of metal ions; Theory of instrumentation and application of colorimetry; Principles and applications of Spectrophotometry [UV- Visible spectrophotometry (UV-VIS)], Atomic Absorption Spectrometry (AAS), Flame Emission Spectrometry and Inductively Coupled Plasma Absorption Emission Spectrometry (ICP-AES and ICP-MS); FTIR; NMR; XRF; XRD; Nephlometry and Turbiditymetry; Chromatography: Paper Chromatography, TLC, GC and HPLC; Electrophoresis, Electron microscopy: GC-MS, SEM, TEM

SUGGESTED READINGS

Chatwal, G.R. and Anand, S.K. 2007. *Instrumental Methods of Chemical Analysis*, Himalaya Publishing House, New Delhi.

Murphy, W.J. 1997. *Analytical Chemistry*, American Chemical Society, USA.

Reeve, R., 2002. *Introduction to Environmental Analysis*, John Willey and Sons, Hoboken, USA.

Rouessac, F. and Rouessac , A. 2007. *Chemical Analysis*: Modern *Instrumentation Methods and Techniques*, Wiley Hoboken, New Jersey, USA.

Skoog, D. A., Holler, F.J., and Crouch, S.R. 2006. *Principles of Instrumental Analysis*, Brooks Cole, London.

Website

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COURSE STRUCTURE

SEMESTER-III

ES 513: RESEARCH METHODOLOGY
CREDIT: (L-T-P) : 3 (3-0-0)

OBJECTIVE

To explain the concept of research, steps in and methods of research, report writing, presentation and research ethics

OUTCOME

The knowledge of research and research methodology could be applied by the learners for doing research and presentation of research output in an ethical manner

CONTENTS

Basics of Research – Definition, Objectives, Motivation, Types, Approaches (Positivism and Post – positive approaches), Significance; Research methods vs Methodology; Research Planning – Characteristics of good research, What to do? How to do?, Problems encountered by a researcher in India; Hypothesis – Meaning, Types, Construction of hypothesis

Research Formulation – Definition , Sources of research problem, Considerations in selecting a research problem, Formulation of research objectives

Review of Literature – Importance, Primary and secondary sources, Web as a source of literature and searching the web; Organization of literature and identifying gap areas from review of literature; Writing research proposal or synopsis

Research Design and Methods – Meaning, Importance, Basic principles; Features of a good research design; Important concepts relating to research design; Different research designs; Basic principles of experimental designs, Developing a research plan

Sampling Design – Census and sample survey; Implications of sample design; Steps in sampling design; Criteria for selecting a sampling procedure; Characteristics of a good sample design; Different types of sample designs

Measurement and Scaling Techniques – Measurement in research, Measurement scales, Sources of error in measurement, Developing measurement tools; Scaling – Meaning, Classification and Techniques

Data Collection – Collection of primary data – Observation method, Interview method, Collection of data through instruments (questionnaires and schedules) and experimentation; Collection of secondary data; Selecting appropriate methods for data collection

Sampling – Need, Definition, Sampling theory; Concept of Standard Error, Estimation – Population mean and population proportion, Sample size and its determination

Data Processing and Analysis – Processing operations; Types of analysis; Statistics in research – Measures of central tendency, Dispersion, Skewness (Asymmetry), Correlation and Regression analysis; Statistical packages of data analysis

Hypothesis Testing – Basic concepts of hypothesis and hypothesis testing, Chi – square test, Analysis of variance and Co – variance, Non – parametric or Distribution – free tests, Multivariate analysis techniques

Report Writing – Interpretation – A pre-requisite for report writing, Meaning of interpretation, Techniques of interpretation, Precautions in interpretation

Research Report – Significance of report, Types of report – Technical report and thesis, Popular report; Structure and components of a scientific report; Steps in report writing; Layout of a typical report – Structure, language, illustrations, tables, bibliographic entries, referencing and footnotes; Writing research papers; Making presentations – oral and poster

Research Ethics and Standards – Commercialization and research; Research ethics – Definition and importance; Research ethics in practice – Intellectual Property Rights, Professional values and qualities of a researcher and sponsoring organization; Detecting unethical research – Plagiarism, paraphrasing and copyright violation; Tools for detecting unethical research; Consequences of plagiarism, Reproducibility and accountability; Valuing research – Citation counting and impact factor, Scientific citation index (SCI), SCI – expanded (SCI – E), H – index

SUGGESTED READINGS

Anthony, M., Graziano, A.M. and Raulin, M.L. 2009. *Research Methods*: *A Process of Inquiry*, Allyn and Bacon, New York.

Banerjee, S. and Ramendu, Roy. 2017. *Fundamentals of Research Methodology*, (3rd Edition), Kitab Mahal, New Delhi.

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Kumar, R. 2014. *Research Methodology: A Step – by – Step Guide for Beginners*, Sage Publications India P. Ltd., New Delhi.

Montgomery D.C. 2001. *Design and Analysis of Experiments*, John Wiley and Sos, New York.

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Snedecor, G.W. and Cochran, G.W. 1989. *Statistical Methods*,8th Edition; Iowa State University Press, Ames, Iowa.

Trochim, W.M.K. 2005. *Research Methods*: *The Concise Knowledge Base*, Atomic Dog Publishing, New Delhi, 270p.

Wadehra, B.L. 2000. *Law Relating to Patents, Trade-marks, Copyright, Designs and Geographical indications*. Universal Law Publishing, New Delhi.

COURSE STRUCTURE
SEMESTER-III

ES 521 LABORATORY III
CREDIT: L–T–P : 4 (0–0–8)

OBJECTIVE

To provide opportunity to learners for hands-on practice on environment-related knowledge inputs as provided to them in courses during classroom learning in the third semester

OUTCOME

To learners would be able to appreciate and realize the importance of practice for theory courses-related inputs, and develop practical skills of analyzing environment and environmental factors

CONTENTS

S. No.	Experiment
1.	To determine total nitrogen in given samples of plant species
2.	To determine phosphate in given samples of plant species
3.	To determine sodium and potassium in given samples of plant species
4.	To determine sulphur content in given samples of plant species
5.	To determine chlorophyll content of selected plant species
6.	To determine protein content of selected plant species
7.	To determine heavy metal concentration (Pb, Cr, and Cd) in biomass of selected plant species
8.	To assess phyto-toxicity of some heavy metals (Pb, Cr, and Cd) on seed germination and seedling growth of selected plant species
9.	To separate a mixture of compound using column chromatography
10.	To separate a mixture of compound using paper chromatography
11.	To determine energy value of different domestic, agricultural and industrial wastes
12.	To study the utilization of waste using earthworm (vermicomposting)
13.	To isolate nitrate from waste water using phytoremediation technique
14.	To study removal of solids and organic matter by constructed wetland system
15.	To measure and record meteorological parameters and geographical location (latitude, longitude and altitude) using automatic weather station and GPS, respectively
16.	To prepare wind rose diagram using given meteorological data
17.	To interpret remote sensing imagery using elements of image interpretation
18.	To determine PM 10 and PM 2.5 concentration in ambient air
19.	To determine sulphur di oxide concentration in ambient air
20.	To determine nitrogen di oxide concentration in ambient air
21.	To determine carbon mono-oxide concentration in ambient air
22.	To determine the Air Quality Index (AQI) based on primary/secondary data

SUGGESTED READINGS

Aneja, K.R. 2018. *Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology*, 5th Edition, New Age International (P.) Ltd. Publishers, New Delhi

APHA.1997. *Standard Methods for Examination of Water and Wastewater*, 21st Edition, American Public Health Association, American Water Works Association and Water Pollution Control Foundation, Washington, D.C.

Jackson, M.L. 1998. *Soil Chemical Analysis*, Revised Edition, Prentice Hall, London.

Kapur, P. and Govil, S.R. 2004. *Experimental Plant Ecology*, CBS Publishers and Distributors, New Delhi, 154 p.

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COURSE STRUCTURE
SEMESTER-IV

ES 502 SEMINAR
CREDIT: (L-T-P): 1 (0-0-2)

ES 506 PROJECT
CREDIT: (L-T-P): 12 (0-0-24)
