CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMMES

Syllabus for

Department of Environmental Science
Nagaland University

2025

Approved by the ____th Academic Council Meeting (AC ____)

Major Courses (Core papers):

Course Code	Title of the Course	Total Credit	
FIRST SEMESTER			
C-1T	Fundamental of Environmental Science	3	
C-1P	Practical 1	1	
C-2T	Environment & Society	3	
C-2P	Practical 2	1	
SECOND SEMESTER			
C-3T	Water and Water Resources	3	
C-3P	Practical 3	1	
C-4T	Land and Soil Conservation and Management	3	
C-4P	Practical 4	1	
THIRD SEMESTER			
C-5T	Biodiversity and Conservation	3	
C-5P	Practical 5	1	
C-6T	Atmosphere and Global Climate Change	3	
C-6P	Practical 6	1	
FOURTH SEMESTER			
C-7T	Systematics and Biogeography	3	
C-7P	Practical 7	1	
C-8T	Urban Ecosystem	3	
C-8P	Practical 8	1	
FIFTH SEMESTER			
C-9T	Environmental Toxicology	3	
C-9P	Practical 9	1	
C-10T	Environmental Economics	3	
C-10P	Practical 10	1	
C-11T	Solid waste Management	3	
C-11P	Practical 11	1	
SIXTH SEMESTER			
C-12T	Organism and Evolutionary Biology	3	
C-12P	Practical 12	1	
C-13T	Natural Resources Management and Sustainability	3	
C-13P	Practical 13	1	
C-14T	Environmental Legislation and Policy	3	

C-14P	Practical 14	1	
C-15T	Energy and Environment	3	
C-15P	Practical 15	1	
SEVEN SEMESTER			
C-16T	Earth and Geomorphic Processes	3	
C-16P	Practical 16	1	
C-17T	Environmental Physics and Chemistry	3	
C-17P	Practical 17	1	
C-18T	Environmental Biotechnology	3	
C-18P	Practical 18	1	
C-19T	Research Methodology	4	
EIGHT SEMESTER			
C-20T	Environmental Management and Impact Assessment	3	
C-20P	Practical 20	1	
C-21T	Research Project/ Dissertation	12	
C-22T			
C-23T			
OR			
EIGHT SEMESTER			
C-20T	Environmental Management and Impact Assessment	3	
C-20P	Practical 20	1	
C-21T	Ecology and Ecosystem	3	
C-21P	Practical 21	1	
C-22T	Environmental Pollution and Human Health	3	
C-22P	Practical 22	1	
C-23T	Remote Sensing and its applications	3	
C-23P	Practical 23	1	

C-1T: Fundamentals of Environmental Sciences

Unit 1: Introduction

Meaning, scope and interdisciplinary nature of Environmental Science; Environmental factors; The Global environment and its segments; Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Theories and concepts- Gaia theory, Environmental Kuznet's curve, Ecological footprint, Environmental ethics, Environmental conventions and treaties.

Unit 2: Natural Resources

Air, Water, Soil, Minerals, Forests and Energy resources; Concept of reserve and resources; Problems with the exploitation of resources.

Energy Fundamentals: Heat transfer processes; Mass and energy transfer across the interfaces of various geospheres, hydrologic cycle and biogeochemical cycles.

Unit 3: Fundamentals of Ecology and Environment

Concept, components and functioning of ecology and ecosystem; Energy fixation and energy flow through food chains and webs; Influence of environmental factors on organisms and their adaptations; Anthropogenic impact on the biosphere and its life support systems; Role of biological processes in remedial measures and restoration.

Suggested Readings

1. Environmental Science - The natural environment and human impact (1998): A. R. W. Jackson and J. M. Jackson, Longman.
2. Environmental Science (2001): S. C. Santra, New Central Book Agency (P) Ltd.
3. Introduction to Environmental Science and Engineering (2nd Ed.) (2004): G. M. Masters, Pearson Education Pvt. Ltd.
4. Fundamentals of Environmental Science: G. S. Dhaliwal, G. S. Sangha and P. K. Raina, Kalyani Publication.
5. Dimensions of Environmental and Ecological Economics (2005): N. C. Sahu& A. K. Choudhury (Ed), Universities Press.
6. Elementary hydrology (1994): V. P. Singh, Prentice-Hall, India.
7. Hydrology – Principles, analysis and design (1996): H. M. Raghunath, New Age International Publisher.
8. Soil erosion and conservation (1993): R. P. Tripathi and H. P. Singh, Wiley Eastern Limited.
9. Integrated watershed management: Rajora.
10. Principles and Practices of Water Management: Panda; Agrobios.
11. River Basin Morphology: Devi; Rajesh Pub.
12. Applied Hydrology-Murtreja.
13. Environment and Ecology: P.D. Sharma.

C-1P: PRACTICAL 1

1. Estimation of minerals from various sources.
2. Quantification of soil nutrients (NPK, Na, Ca).

3. Visit to forest ecosystem and studies on vegetation mapping.
4. Studies on Gene pool of forest ecosystems using curated databases.
5. Case studies on river linking and its implications.

C-2T: ENVIRONMENT & SOCIETY

Unit 1: Introduction

Social and cultural construction of 'environment'; environmental thought from historical andcontemporary perspective in light of the concepts of Gross Net Happiness and Aldo Leopold's LandEthic; historical developments in cultural, social and economic issues related to land, forest, and watermanagement in a global context; interface between environment and society.

Unit 2: Development-environment conflict

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

Unit 3: Community participation

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

Suggested Readings

1. Chokkan, K.B., Pandya, H. & Raghunathan, H. (eds). 2004. Understanding Environment. Sagar Publication India Pvt. Ltd., New Delhi.
2. Elliot, D. 2003. Energy, Society and Environment, Technology for a Sustainable Future. Routledge Press.
3. Guha, R. 1989. Ecological change and peasant resistance in the Himalaya. Unquiet Woods Oxford University Press, Delhi.
4. Leopold, A. 1949. The Land Ethic. pp. 201-214. Chicago, USA.
5. National Research Council (NRC). 1996. Linking Science and Technology to Society's Environmental Goals. National Academy Press.
6. Pandit, M.K. 2013. Chipko: Failure of a Successful Conservation Movement. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 126-127. Wiley-Blackwell, Oxford, UK.

C-2P: Environment & Society

a. Evaluation of constituents of municipal solid waste (MSW).
b. Survey for sustainability in rural areas of Nagaland like food, water, energy, etc.
c. Survey of impact of population growth in urban area
d. Survey of gender equality in education

C-3T**: WATER AND WATER RESOURCES**

Unit 1: Introduction

Sources and types of water, Hydrological cycle, Precipitation, Runoff, Infiltration, Evaporation, Evapotranspiration, Temperature, Colour, Odour, Turbidity, Major inorganic and organic constituents, dissolved gases, DO, Phytoplankton, phytobenthos, Zooplanktons, Micro and macro invertebrates in water, Surface and ground water, Water table, Aquifers, Techniques for ground water recharge, Rivers, Lakes and Estuaries, Watershed and drainage basins, Water resources in India, Water supply, demand and use in India.

Unit 2: Water resource management

Concepts of watershed management, Rain water harvesting, Wetlands and their significance, threats, conservation and management, Ramsar Convention, 1971 and major wetlands of India, Marine water resources and their threats and conservation, National water policy, Indus water treaty; Ganges water treaty; Teesta water treaty; National River linking plan and its ecological and economic impacts, River basin management, Flood management, Integrated Water Resource Management (IWRM).

Unit 3: Water resources conflicts

Water resources scarcity, competition, and unequal distribution, Intrastate and Transboundary conflicts, Case studies on Kaveri and Krishna river water disputes, Multipurpose river valley projects in India and their environmental and social impacts, Case studies of dams - Narmada and Tehri dam, Social and ecological losses versus economic benefits; International conflicts on water sharing between India and itsneighbors, Conflict resolution strategies and Water governance.

Suggested Readings

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

C-3P**: Practical 3**

1. To study confined aquifer and unconfined aquifer.
2. Delineation and Morphometric analysis of watershed.

3. Determination of pH, Electrical Conductivity and Turbidity of water sample.
4. Determination of Chloride in water sample by $AgNO_3$ method.
5. Estimation of Phosphates in water by Ammonium Molybdate method.
6. Estimation of Sulphates in water sample.
7. Estimation of nitrates in water sample.
8. Estimation of fluorides in water sample.

C-4T: LAND AND SOIL CONSERVATION AND MANAGEMENT

Unit 1: Introduction and Fundamentals of soil science

Soil formation, Classification of soil, soil architecture, Soil texture and soil textural triangles,Water holding capacity, Moisture content, Organic matter, Role of anion and cations in soils, Temperature; Bulk density, Porosity, Plasticity, Soil colloids,Soil salinity, Acidic soils, Sodic soils, Micro-Macro nutrients of soil, Soil microbes,Major soil types, Soil health, Soil fertility, Land resource types, uses and change, Soil biogeochemical cycles.

Unit 2: Land use change and Land-Soil degradation

Degradation of soils, Soil erosion and its control, Non-erosive and erosive soil degradation; Losses of soil moisture; Nutrient depletion, Causes of Soil degradation, Toxic organic contaminants in soils, Loss of soil fertility due to chemical fertilizers and its management; Biological and physical phenomena in land degradation, Visual indicators of land degradation, Drivers of land degradation, Land salinization, Land use and land cover change and its examples, Socio-economic effects of land and soil degradation, Economic valuation of land and soil degradation, Shifting cultivation.

Unit 3: Land and soil conservation and management

Sustainable land use practices, Land use – land cover planning, Role of databases and data analysis in land useplanning control and management, Legal, institutional and sociological factors, Participatory land degradation assessment, Integrating land degradation assessment into conservation, Land pool, Soil health cards, Soil fertility management, Irrigation and drainage management and its role in soil conservation, pasture and grazing land management

Suggested Readings

1. Brady, N.C. and Well, R.R. 2007.The Nature and Properties of Soils (13th edition), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio 22: 167-172.
3. Johnson, D.L. 2006. Land Degradation (2nd edition). Rowmanand Littlefield Publishers.
4. Marsh, W. M. andDozier,J. 1983. Landscape Planning: Environmental Applications. John Wiley and Sons.
5. Pandit, M.K. et. al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163.
6. Peterson, G. D., Cumming, G. S. and Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology 17: 358-366.

7. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020? (Vol. 27). International Food Policy Research Institute

C-4P**: Practical 4**

1. Determination soil texture by soil textural triangle.
2. Determination of porosity of the soils.
3. Determination of the plasticity of the soils.
4. Estimation of calcium and magnesium content of soil.
5. Comparing soil erosion by Contour Plowing Experiment.
6. Estimation of micronutrients of soil.
7. Identification of gram positive and gram-negative bacteria in soil samples.
8. Infiltration Rate Measurement of the soil by using ring infiltrometer.

C5T: BIODIVERSITY AND CONSERVATION

Unit 1: Biodiversity patterns and biodiversity estimation

From genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic time scale; Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation. India as a mega diversity nation; Phytogeographic and zoogeographic zones of India; Flora and Fauna of India;Forest types and forest cover in India.

Sampling strategies and surveys;Qualitative and quantitative methods; community diversity estimation; Molecular techniques; Economic values; Ecological and ecosystem services.

Unit 2: Threats to biodiversity

Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; Man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis; Impact of development projects on biological diversity in India

Unit 3: Conservation of biodiversity

In-situ conservation; Ex-situ conservation;Role of local communities and traditional knowledge in conservation; Biodiversity hotspots; IUCN Red List categorization; Red Data book; Ecological restoration; Afforestation; Social forestry; Agro forestry; Joint forest management; Role of remote sensing in management of natural resources; Status of protected areas and biosphere reserves in India; National Biodiversity Action Plan.

Suggested Readings

1. Gaston, K J. and Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.
2. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

3. Pandit, M.K. and Grumbine R.E. 2012. Ongoing and proposed hydropower development in the Himalaya and its impact on terrestrial biodiversity. Conservation Biology 26:1061-1071.
4. Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.
5. Singh, J. S. and Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review 53: 80-192.
6. Singh, J. S., Singh, S.P. and Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
7. Sodhi, N.S. and Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.
8. Sodhi, N.S., Gibson, L. and Raven, P.H. 2013. Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK

C-5P**: Practical 5**

1. Identification of wild animals by using pug marks.
2. Identification of wild species by using feeding signs and artifacts.
3. Determination of relative abundance of light attracting insects by using light trap.
4. Determination of bird population by using Lincoln index (Simulation)
5. Determination of total population /density of birds from nesting ground during breeding season / or determination of total population of birds by using nests.
6. Identification of mammals from the hair morphology and histology.
7. To study the bird species by using vocal display.
8. Determination of burrowing animal's population by using their artifacts.
9. Field visit for the study of wild species and collection of samples from various domestic and wild animals.
10. Visit to Zoo/ National park /Sanctuary /Aquarium for the study of wildlife.
11. Field visit to study the habitat components of wild species.

C-6T: ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Unit 1: Meteorology and atmospheric stability

Meteorological parameters; Atmospheric stability and mixing heights; Temperature inversion; Plume behavior; Gaussian plume model.

Movement of air masses; Atmosphere and climate; Air and sea interaction; Southern oscillation; Western disturbances; El Nino and La Nina; Tropical cyclone; Indian monsoon and its development; Changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; Effect of urbanization on micro climate; Asian brown clouds.

Unit 2: Atmospheric chemistry

Evolution and development of Earth's atmosphere; Atmospheric structure, compositionits significance; Milankovitch cycles; Chemistry of atmospheric particles and gases; Smog – types and processes; Photochemical processes; Ions and radicals in atmosphere; Acid-base

reactions in atmosphere; Atmospheric water; Role of hydroxyl and hydroperoxyl radicals in atmosphere.

Ozone layer or ozone shield and its importance; Ozone layer depletion and causes; Chapman cycle; Process of spring time ozone depletion over Antarctica; Ozone depleting substances (ODS); Effects of ozone depletion; Mitigation measures and international protocols.

Unit 3: Global warming and climate change

Earth's energy balance; Energy transfers in atmosphere; Earth's radiation budget; Greenhouse gases (GHGs); Greenhouse effect; Global conveyor belt; Earth's climate through ages; Trends of global warming and climate change; Drivers of global warming and the potential of different GHGs causing the climate change; Atmospheric windows; Impact of climate change; Impact on economy and spread of human diseases.

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

Suggested Readings:

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

C-6P: Practical 6

1. Study of meteorological instruments.
2. Determination of Maximum and Minimum temperature using psychomotor.
3. Determination of relative humidity in ambient atmosphere.
4. Determination of solar radiation and illuminations.
5. Study of precipitation, rainfall analysis and Indian monsoon patterns.
6. Determination of wind speed and direction by anemometers
7. Estimation of ambient carbon dioxide.
8. Study of clouds and their types.
9. Study of Wind roses and pollution roses.
10. Community perception on climate change–Questionnaire method.

11. Quantification of greenhouse gas emissions from a) Energy sector, b) Industrial sector, c) Agriculture and forestry sector, and d) Waste sector.

C-7T: Systematics and Biogeography

Unit 1: Concept and systematics approaches

Definition of systematics; Taxonomic identification; Keys; Field inventory; Herbarium; Museum; Botanical gardens; Taxonomic literature; Nomenclature; Evidence; Taxonomy databases.

Concept of taxa, species, categories and taxonomic hierarchy; Principles and rules; Ranks and names; Types and typification; Author citation; Valid publication; Rejection of names; Principle of priority and its limitations; Names of hybrids; Classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification. Characters.

Variations; Operational Taxonomic Units; Character weighting and coding; Phenograms; cladograms; DNA barcoding; Phylogenetic tree; Clades; Homology and analogy; Parallelism and convergence.

Unit 2: Speciation and extinction Historical Biogeography

Genes as unit of evolutionary change; Mutation; Genetic drift; Gene flow; Natural selection; Geographic and ecological variation; Biogeographical rules; Biogeographical realms and their fauna; Endemic, rare, exotic, and cosmopolitan species; Types and processes of speciation; Ecological diversification; Adaptive radiation, convergent and parallel evolution; Dispersal and immigration; Means of dispersal and barriers to dispersal; Extinction.

Earth's history; Paleo-records of diversity and diversification; Continental drift and plate tectonics and their role in biogeographic patterns; biogeographical dynamics of climate change and Ice Age.

Unit 3: Ecological Biogeography and Conservation Biogeography

Species' habitats; Environment and niche concepts; Biotic and abiotic determinants of communities; Species-area relationships; Concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; Geography of diversification and invasion; Phylogeography. Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

Suggested Readings

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

C-7P: Practical 7

1. Field and Herbarium techniques: Description and identification of plants; identification test of plant specimens; study of Nagaland flora; Vegetation quantification; field sampling.
2. Estimation of quantitative and qualitative characteristics of community: frequency, density, abundance, basal area, physiognomy, phenology and productivity

C-8T: Urban Ecosystem

Unit 1: Introduction

Introduction to urbanization; Urban sprawl and associated environmental issues.

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

Unit 2: Urban dwelling and interface with the environment

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

Management of urban environment; Alternative resources; Policy and management decisions; Urban settings as loci of sustainability; Challenges associated with sustainability and urban future.

Unit 3: Planning and environmental management

Concept of 'controlled nature'; Scope, importance and threats to nature in the city; Organization and planning of green spaces such as parks, gardens and public spaces; Concept of green belts, green infrastructure, sponge cities; Urban natural forest ecosystem as green lungs.

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

Suggested Readings

1. D'Monte, Darryl. 1985. Industry versus Environment Temples or Tombs. Three Controversies, Delhi, CSE.
2. Ernstson, H. 2011. Re-translating nature in post-apartheid Cape Town: The material semiotics of people and plants at Bottom Road. In: Heeks, R., (Ed.) Conference on "Understanding Development through Actor-Network Theory", London School of Economics, 30 June, London.
3. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
4. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science 319: 756-760.

5. Hinchliffe, S. and Whatmore, S. 2006. Living cities: Towards a politics of conviviality. Science as Culture 15: 123–138.
6. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban' between the social and natural sciences. Urban Ecosystems 4: 5-24.
7. Montgomery, M.R. 2009. Urban Transformation of the developing world. Science 319: 761-764.
8. Richter, M. and Weiland, U. (ed.). 2012. Applied Urban Ecology. Wiley-Blackwell, UK

P-8T: Practical 8

1. Estimation of particulate matter, sulphur dioxide and oxides of nitrogen in ambient air.
2. Determination of relative density of sewage sample.
3. Estimation of volatile solids from sewage sample by gravimetric analysis.
4. Determination of Sludge Volume Index (SVI) in the sewage sample.
5. Determination of Total, settleable, suspended and dissolved solids in wastewater sample.
6. Determination of Hardness, Fluoride, Chlorides, DO, BOD COD in wastewater sample.
7. Determination of dose of chorine for disinfection of sewage.
8. Determination of Urban Infrastructure Index (UFI).
9. Determination of Water Quality Index (WQI).
10. Determination of Environmental Pollution Index (EPI).
11. Determination of life quality index.
12. Determination of Comprehensive environmental pollution index (CEPI).

C9T: ENVIRONMNETAL TOXICOLOGY

Unit 1: Overview of Environmental Health

Concept and scope of Environmental Health; Environmental health criteria; Historical review of human impact on the environment; Basic requirements for healthy environment; Risk verses benefits; Does-Response relationships: Graded response, quantal response, time action curves threshold limit value (TLV); margin of safety, toxicity curves; Environmental toxicity testing: scope, process and limitation; Introduction to environmental contaminants monitoring.

Unit 2: Environmental Health Hazard

Biological, chemical, physical and psychological health hazard; Asbestosis, Silicosis, Sinusitis, Asthma, Fluorosis and Allergies; Bio-transformation, bio-accumulation and bio-magnification: Principles, receptor sites absorption and storage of xenobiotics; Types of bio-transformations, toxico-genomics and pharmacogenomics; Influence of ecological factors on the effects of toxicity.

Unit 3: Eco-toxicology & Human health: Toxicity testing

Bioassay-Definition, purpose, criteria for selection of test organism methodology, estimation of LC50, limitation and importance of bioassay, acute toxicity (single), Sub acute toxicity, chronic toxicity, teratogenicity, and mutagenicity; Assessment of risks to human; Bioactive substances and their significance in the ecosystem; Food as source of toxicity to environmental pollutants; Transport through food chain - bio-transformation and biomagnification; Clinical toxicology; Detoxification in human body.

Suggested Readings

1. Shaw, I.C. and Chadwick, J., Principles of Environmental Toxicology, CRC Press, 1998.
2. Yassi, A., Kjellstrom, T., Kok, T.de., Guidotti, T., Basic Environmental Health,Oxford University Press, 2001.
3. Morgan, M.T., Environmental Health (2nded.), McGraw-Hill Ryerson Limited, 2003.
4. Koren, H., Handbook of Environmental Health and Safety–principle and practices (Vol. 2), Lewis Publishers, Chelsea, U.K., (1991)

C-9P: Practical 9

12. Acquaintance with commonly used equipment such as Atomic Absorption Spectrophotometer/ spectrophotometer/Flame photometer.
2. Estimation of metals in Air/ Soil / Water samples using spectrophotometer/ Atomic Absorption Spectrophotometer.

C10T: ENVIRONMENTAL ECONOMICS

Unit1: Introduction to microeconomics

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

Unit 2: Environmental economics

Main characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Pareto principle or criterion; Hardin's Thesis of 'The Tragedy of Commons'; prisoner's dilemma game; methods of abatement of externalities; social cost benefit analysis; cost-effectiveness analysis.

Unit 3: Tools for environmental economic policy

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

Suggested Readings

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

C10P**: Practical 10**

1. Calculation of mean, mode & median of data.
2. Calculation of standard deviation and co-efficient of variation of data.
3. Calculation of Karl Person's Co-efficient of Co-relation.
4. Calculation of Regression from the data.
5. Calculation of variance and standard error (SE) from data.
6. Problems on probability, t-test, Z-test, and f-test.
7. Application of statistical software for studying environmental statistics

C-11T**: SOLID WASTE MANAGEMENT**

Unit 1: Types, sources and effects and treatment of solid wastes

Sources and generation of solid waste, their classification and chemical composition, Characterization of municipal solid waste, Hazardous waste, Biomedical waste, E-waste, Plastic waste, Impact of solid waste on environment, human and plant health, Mining waste, SWMprocesses, Sanitary landfills, Land fill leachate and its effects, Pyrolysis, incineration, Valorization of waste material, Industrial waste management, Sewage sludge management.

Unit 2: Resource Recovery and Waste- to- energy (WTE) technologies

4R- reduce, reuse, recycle and recover, Biological processing of waste - composting, anaerobic digestion, aerobic treatment, reductive dehalogenation, mechanical biological treatment. Green techniques for waste treatment, Concept of energy recovery from waste, refuse derived fuel (RDF); different WTE processes,combustion, pyrolysis, landfill gas (LFG) recovery, Anaerobic digestion, Gasification.

Unit 3: Integrated waste management and policies

Concept of Integrated waste management- Waste management hierarchy, Methods and importance, Cradle to grave approach, Lifecycle inventory of solid waste, Role of LCA in waste management, Advantage and limitation of LCA, Case study on LCA of a product, Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly or green products.

Suggested Readings

1. Asnani, P. U. 2006. Solid waste management. India Infrastructure Report 570.
2. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley and Sons.
3. Blackman, W.C. 2001. Basic Hazardous Waste Management. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M., and Hindle, P. 2008. Integrated Solid Waste
5. Management: A Life Cycle Inventory. John Wiley and Sons.
6. US EPA. 1999. Guide for Industrial Waste Management. Washington D.C.
7. White, P.R., Franke, M. andHindle P. 1995. Integrated Solid waste Management: A Lifecycle
8. Inventory. Blackie Academic and Professionals.
9. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. and Mani, S. 2008. Improving Municipal Solid waste Management in India. The World Bank, Washington D.C.

C11P**: Practical 11**

1. To assess the lifecycle of different industrial product from cradle to grave.
2. To study the recycling, reuse and disposal practices of different industrial wastes.
3. To study zero waste technology of any two industrial units.
4. To study in detail on the provisions of ISO 14000, with respect to green product design.
5. To study bio-fuel production methods and characterization for biodiesel and bio-ethanol.

C12T**: ORGANISM AND EVOLUTIONARY BIOLOGY**

Unit 1: History of life on Earth

Paleontology; Evolutionary time scale; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo sapiens; Lamarck's concept of evolution; Darwin's Evolutionary Theory; Mendelism; Spontaneity of mutations; The Evolutionary Synthesis.

Unit 2: Evolution of unicellular life

Origin of cells and unicellular evolution and basic biological molecules; Abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; Evolution of prokaryotes and unicellular eukaryotes; Anaerobic metabolism, Photosynthesis and aerobic metabolism.

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

Neutral evolution; Molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; Origin of new genes and proteins; Gene duplication and divergence.

Unit 3: Fundamentals of population genetics

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

Suggested Readings

1. Futuyma, D.J. 2009. Evolution (2nd edition). Sinauer Associates.
2. Gillespie, J. H. 1991. The Causes of Molecular Evolution. Oxford University Press.
3. Graur, D. and Li, W.H. 1999. Fundamentals of Molecular Evolution (2nd edition). Sinauer Associates.
4. Kimura, M. 1984. The Neutral Theory of Molecular Evolution. Cambridge University Press.
5. Minkoff, E.C. 1983. Evolutionary Biology. Addison Wesley. Publishing Company.
6. Nei, M. and Kumar, S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press.
7. Nei, M. 1975. Molecular Population Genetics and Evolution. North-Holland Publishing Company.
8. Nei, M. 1987. Molecular Evolutionary Genetics. Columbia university press.
9. Thorne, J. L., Kishino, H., and Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. Molecular Biology and Evolution 15: 1647-1657

ENV-C12P**: Practical 12**

1. Calculation of different biodiversity indices
2. Calculations based on population genetics

C13T**: NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY**

Unit 1: Introduction and Resource management

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability

science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

Unit 2: Natural resources and conservation

Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

Unit 3: Renewable and Non-renewable energy resources

Energy efficiency of renewable resources; solar energy; hydropower; nuclear power, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel; Non-renewable energy source; Oil: formation, exploration, extraction and processing; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non-renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges.

Suggested Readings

1. Craig, J.R., Vaughan. D.J. and Skinner. B.J. 1996. Resources of the Earth: Origin, Use, andEnvironmental Impacts (2nd edition). Prentice Hall, New Jersey.
2. Freeman, A.M. 2001. Measures of value and Resources: Resources for the Future. Washington DC.
3. Freeman, A.M. 2003. Millennium Ecosystem Assessment: Conceptual Framework. Island Press.
4. Ginley, D.S. and Cahen, D. 2011. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press.
5. Klee, G.A. 1991. Conservation of Natural Resources. Prentice Hall Publication.
6. Miller, T.G. 2012. Environmental Science. Wadsworth Publishing Co.
7. Owen, O.S, Chiras, D.D, andReganold, J.P. 1998. Natural Resource Conservation – Management for Sustainable Future (7th edition). Prentice Hall.
8. Ramade, F. 1984. Ecology of Natural Resources. John Wiley and Sons Ltd.
9. Tiwari, G.N. and Ghosal. M. K. 2005. Renewable Energy Resources: Basic Principles and

C-13P**: Practical 13**

1. To assess the lifecycle of different industrial product from cradle to grave.
2. To study the recycling, reuse and disposal practices of different industrial wastes.
3. To study zero waste technology of any two industrial units.
4. To study in detail on the provisions of ISO 14000, with respect to green product design.

5. To study on ecollabelling from pharmaceuticals, foods, cosmetics, automobiles and electronic industry.
6. To assess the impact of materials on biodiversity, resources and ecosystems.
7. To study bio-fuel production methods and characterization for biodiesel and bio-ethanol.
8. To study the application of green chemistry concept in industries.
9. To study application of green chemistry concept in agricultural related practices and food processing units.
10. To study in detail the concept of green building in urban areas.

C14T**: ENVIRONMENTAL LEGISLATION AND POLICY**

Unit 1: History of environmental legislation and policy

Stockholm Conference and world Earth summits, Rio 92, UNFCCC, Agenda 21, Paris agreement; NDCs, Historical environmental provisions and conservation in India literatures, Environmental provisions in Indian constitution, National Green Tribunal, Forest Act 1865, The Indian Forest Act 1927, The Forests (Conservation) Act 1980; Van Mahotsava, National Forest Policy 1952, Case studies on Indian Environmental laws and policies.

Unit 2: Environmental legislation, principles and Government institutions

Legal definitions- environmental pollution, natural resource, biodiversity, forest, sustainable development, Law of tort, Writ petitions, PIL, Polluter pays principle, Precautionary Principle, Intergenerational Equity, Public Trust Doctrine, Role of Ministry of Environment, Forests and Climate Changein environmental law and policy making, Role of central and state pollution control boards in environmental law and policy making, Role of NGOs in environmental conservation.

Unit 3: Legislative Instruments

The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988 and amendment, The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010, SWM rules, 2016, Plastic waste management rules, 2016

Suggested Readings

1. Abraham, C.M. 1999. Environmental Jurisprudence in India. Kluwer Law International.
2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. Bulletin of the National Institute of Ecology 15: 227-238.
3. Divan, S. and Rosencranz, A. 2001. Environmental Law and Policy in India. Oxford University Press.

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

C14P: Practical 14

1. Study on International and National standard of Air, Water and Soil
2. Study in detail on Environmental accounts, auditing, green funding, and taxes trade and environmental management in any two industrial units.
3. To evaluate the adverse effect of lack of environmental planning in industries (any two)
4. To prepare base line data on water, soil, air, natural assets, demography, and heritage of any two project areas.
5. Study of rural and urban environmental planning at regional level.
6. Study on resource planning at regional and national level.
7. Study on Gandhian concept of self-relied villages.
8. To study the Ramsar Convention on wetlands with few case studies.
9. To study the application of Vienna Convention Montreal protocol and kyoto protocol in India.

C15T: ENERGY AND ENVIRONMENT

Unit 1: Energy resources and Demand

Defining energy, forms and importance; Energy use from a historical perspective; Sources and sinks of energy; Global energy resources; Renewable and non-renewable resources: distribution and availability; Technologies for capturing and integrating these resources into energy infrastructure; Energy-use scenarios in rural and urban setups.

Global energy demand: historical and current perspective; Energy demand and use in different sectors; Generation and utilization in rural and urban environments; Energy over-consumption in urban setting; Changes in demand in major world economies; Energy subsidies and environmental costs.

Unit 2: Energy, environment and society

Nature, scope and analysis of local and global impacts of energy use on the environment; Fossil fuel burning and related environmental issues; Nuclear energy and related issues.

Current and future energy use patterns in the world and in India; Evolution of energy use over time; Alternative sources as green energy; Need for energy efficiency; Energy conservation and sustainability; Action strategies for sustainable energy mix and management from a future perspective.

Unit 3: Energy, ecology and the environment

Energy production as driver of environmental change; Energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); Energy over-consumption and its impact on the environment, economy, and global change; Political choices in energy policy globally and in the Indian context (historical and contemporary case studies); Domestic and international energy policy; Energy diplomacy and bilateral ties of India with her neighbors.

Suggested Readings

1. McKibben, B. 2012. Global Warming's Terrifying New Math, Rolling Stone Magazine.
2. Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. Resources of the Earth: Origin, use, and environmental impact (2nd edition). Prentice Hall, New Jersey.
3. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.
4. Rowlands, I.H. 2009. Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.
5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics
6. and Public Policy, June-July.
7. Mallon, K. 2006. Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making. Earthscan.

C15P: Practical 15

1. Study of ISO: 14000 and OSHAS 18000
2. Studies on LCA of pulp and paper industry, food industry and crop plants.
3. To study zero waste technology of any two industrial units.
4. To study in detail on the provisions of ISO 14000, with respect to green product design.
5. To study on ecolabelling from pharmaceuticals, foods, cosmetics, automobiles and electronic industry.
6. To assess the impact of materials on biodiversity, resources and ecosystems.
7. To study bio-fuel production methods and characterization for biodiesel and bio-ethanol.
8. To study the application of green chemistry concept in industries.
9. To study application of green chemistry concept in agricultural related practices and food processing units.
10. To study in detail the concept of green building in urban areas.
11. To study the chemical reactive, involve in green nanotechnology, nano-particle production and characterization.

C-16T**: EARTH AND GEOMORPHIC PROCESSES**

Unit 1: History of Earth

Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age; Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere; Convection in Earth's core and production of its magnetic field.

Unit 2: Earth system processes

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

Unit 3: Earth surface processes

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

Suggested Readings

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

C-16P**: Practical**

1. Study of terrain characteristics using topo sheets.
2. Study of micrometeorological equipment.
3. Determination of relative humidity of air.
4. Determination of atmospheric pressure by using Barometer.
5. Determination of wind speed by using Anemometer.
6. Determination of wind direction by using wind vane.
7. Interpretation of wind rose diagram.

C-17T**: ENVIRONMENTAL PHYSICS AND CHEMISTRY**

Unit 1: Fundamentals of environmental physics

Basic concepts of light and matter, Electromagnetic spectrum, Kirchhoff's law, Boltzmann equation, spectroscopic concepts, Beer–Lambert law, photovoltaic solar cells, Scattering of light, Basic concepts of pressure, force, work and energy, Conduction, Convection; Lapse rate, Laws of thermodynamics, concept of heat and work, Efficiency of turbines, wind mills and hydroelectric power plants.

Unit 2: Fundamentals of environmental chemistry

Atomic structure, Electronic configuration, Periodic properties of elements, Chemical bonds, Molarity and Normality, Chemical speciation, Concepts of acid, baseand salt, Solubility products, solutes and solvents, Redox reactions, Concepts of pH and pE, Basic concepts of organic chemistry, Hydrocarbons, Aliphatic and aromatic compounds, Organic functional groups, Polarity of the functional groups, Titrimetry and gravimetry, Carbonate chemistry in water.

Unit 3: Water and soil chemistry

Physico-chemical properties of water; pH, EC, Alkalinity, Hardness, TDS, TSS, TS, Solubility of metals, Complex formation and chelation, Colloidal particles, Soil composition, Inorganic and organic components in soil, Organic carbon, Soil humus; Cation exchange capacity, Role of NPK in soil, Phenolic compounds in soil, Sodium adsorption ratio.

Suggested Readings

1. Beard, J.M. 2013. Environmental Chemistry in Society (2nd edition). CRC Press.
2. Boeker, E. and Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.
3. Connell, D.W. 2005. Basic Concepts of Environmental Chemistry (2nd edition). CRC Press.
4. Forinash, K. 2010. Foundation of Environmental Physics. Island Press.
5. Girard, J. 2013. Principles of Environmental Chemistry (3rd edition). Jones and Bartlett.
6. Harnung, S.E. and Johnson, M.S. 2012. Chemistry and the Environment. Cambridge University Press.
7. Hites, R.A. 2012. Elements of Environmental Chemistry (2nd edition). Wiley and Sons.
8. Manahan, S. E. 2000. Fundamentals of Environmental Chemistry. CRC Press.
9. Pani, B. 2007. Textbook of Environmental Chemistry. IK international Publishing House.

C-17P**: Practical**

1. Studies on the concept of molarities, normality and buffer solutions.
2. Determination of organic matter by Walkley's and Black method from soil.
3. Determination of bicarbonate and carbonate alkalinity of water.
4. Determination of pH and Electrical conductivity of water and soil samples.

5. Determination of water holding capacity, Bulk density and moisture content of soil.
6. Estimation of calcium and magnesium content of soil.
7. Estimation of available phosphates and total nitrogen in soil.
8. Determination of water hardness by titrimetric method.
9. Determination of TS, TDs, and TSS in water samples.

C-18T: ENVIRONMENTAL BIOTECHNOLOGY

Unit 1: Structure and Function of Nucleic acids and Protein

Structural, physical and chemical characteristics of Nucleic acids (DNA and RNA); Synthesis of nucleic acids; Biological significance of nucleic acids; Types and chemical characteristics of amino acids; Structural, physical and chemical characteristics of Protein; Synthesis and posttranslational modifications of proteins and their significance; Types, function and role of enzymes; Central dogma; Genetic material in viruses, prokaryotes, eukaryotes and organelles; Mobile DNA; Chromosomal organization.

Unit 2: Recombinant DNA Technology

Concept of Recombinant DNA (rDNA) and genetic engineering; Steps involved in genetic engineering; Enzymes used for manipulation and modification of DNA; Construction, screening and application of genomic and cDNA libraries; Cloning and expression vectors; Nucleic acid microarrays.

Unit 3: Ecological restoration and bioremediation

Anaerobic and aerobic process of wastewater treatment and their applications; Bioreactors; Cell and protein (enzyme) immobilization techniques; Solid waste sources and management; Composting and vermiculture technology; Methane production; Landfill; Bioremediation technologies: land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wetlands, use of bioreactors; Phytoremediation; Remediation of degraded ecosystems; Degradation of xenobiotics; Application of genetically modified microbes in oil pollution, pesticides, heavy metals; Biofertilizers; Biopesticide; Integrated pest management; Development of stress tolerant plants; Biofuel; Biomining.

Suggested Readings

1. Evans, G.G. and Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2nd edition). Wiley-Blackwell Publications.
2. Jordening, H.J. and Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wileyand Sons.
3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. and Darnell, J. 1995. Molecular Cell Biology. W.H. Freeman.
4. Nelson, D.L. and Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.
5. Rittman, B.E. and McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. McGraw-Hill, New York.
6. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press.

7. Snustad, D.P. and Simmons, M.J. 2011. Principles of Genetics (6th edition). John Wileyand Sons.
8. Wainwright, M. 1999. An Introduction to Environmental Biotechnology. Springer

C-18P**: Practical**

1. Preparation of culture media and study of colony characteristics.
2. Micrometry and Haemocytometer.
3. Isolation and Identification of fungal and bacterial colonies from air and soil.
4. Bacterial examination of water–Total and Faecal coliforms by MPN and MF techniques.
5. Determination of *Escherichia coli* in water – MPN, Plate count, and Membrane filtration techniques
6. Isolation and identification of bacteria and fungi from fruits and vegetables.
7. Isolation and identification of bacteria and fungi from touch surface of working places.
8. Study of phylloplane/ rhizosphere microflora.
9. Biochemical tests a) Indole test, b) Methyl red, c) Vogues Proskaeur test, d)Citrate utilization test, e)Catalase test, f) Oxidase test, g) Urease test, h) Sugar fermentation test, i) Gelatin hydrolysis, j) Casein hydrolysis, and k) Amylase production.
10. Antibiotic sensitivity tests.
11. To study morphology of yeast cell by negative staining technique.
12. Developing stir tank reactor / suspension reactor for *Ex-situ* bioremediation.
13. Estimation of protein, carbohydrates, fats and amino acid content in biological samples.

C-19T: RESEARCH METHODOLOGY

Unit 1: Research Methodology

Objectives and motivations in research; Characteristics and limitations of research; Components of research work; Criteria of good research, Research process; Types of Research; Fundamental, Pure or Theoretical Research, Applied Research, Descriptive Research, Evaluation Research, Experimental Research, Survey Research, Qualitative Research, Quantitative Research.

Unit 2: Research Design Formulation:

Research Design – definition – essentials and types of research design – errors and types of errors in research design. Research problem: Selecting and analyzing the research problem – problem statement formulation – formulation of hypothesis. Variables in Research – Measurement and scaling, Different scales, Construction of instrument, Validity and Reliability of instrument.

Unit 3: Research Publication Ethics :

Publication Ethics: Definition, Introduction and Importance, Conflicts of Interest, Best practices/standards initiatives, and guidelines: COPE, EAME, etc. Plagiarism, Self-Plagiarism, Software for detection of Plagiarism. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice-versa, types, complaints and appeals.

Unit 4: Code of Ethics in Research

Ethical issues in research: Code of Ethics in Research, Violation of publication ethics, authorship and contributorship, Intellectual Property Rights, Ethics related to Participants and Researchers: Copyright; Royality, Patent Law, Citation, Acknowledgment, Predatory publishers and journals.

Suggested Readings

1. Agricultural Statistics in India: Chadda, A. (1989);Suman Book House, New Delhi.
2. An Introduction to database system: Date, C. J. (1986); Addision Wesley, U.K.
3. Research Methodology for Biological Sciences: Gurumani, N. (2006); MJP Publishers, Chennai.
4. Environmental Statistics: Methods and Applications: Barnett, Vic (2006); John Wiley and Sons, New Delhi.
5. Fundamentals of Mathematical Statistics: S. C. Gupta and V. K. Kapoor; S. Chand & Co.
6. Statistical Methods in Geographical Studies: Aslam Mahmood; Rajesh Publications, New Delhi.
7. Statistical Methods: An Introductory Text :J.Medhi; New Age International Ltd. Publishers.

C-20T: ENVIRONMENTAL MANAGEMENT AND IMPACT ASSESSMENT

Unit 1: Environmental Management Systems:

Concept, scope, approaches and benefits of EMS, International and National accreditation systems- ISO-14000 & 14001, IS & BIS, Environmental auditing- Scopeand objectives, standards, procedures and benefits, Ecotourism, Eco-restoration; Ecomark, Environmental/Green tax; Principles of clean production and Packaging, Total Environmental Quality Management (TQEM); Ecolabelling, Ecological and Carbon footprints.

Unit-2: Environmental Impact Assessment, tools and techniques

Origin and Development of EIA, Definitions, Objectives, Scope and Advantages of EIA, The EIA Processes, Evaluation and mitigation, EnvironmentalManagement Plan (EMP), Public consultation and participation, EIS, CIA and CIR, Life cycle assessment, Assessmentmethodologies- Ad-hoc, Overlay, Network, Matrix, Checklist; PostEIA Monitoring and Auditing.

Unit-3: EIA regulations in India:

The Indian EIA regime- Notifications, Guidelines, Project categories requiring Environmental Clearance (EC), Public hearing process in India, EIA amendments, Procedure for EC, EIA expert committee and Stakeholders, Benefits and drawbacks of EIA in India, EIA case studies- River valley projects, Mining, Power plants, Highways etc.

Suggested readings:

1. Oberoi, N.K, Environmental Management, (2nd ed.), Excel Books, New Delhi, 2004.
2. Glasson, J., Therival, R., Introduction to Environmental Impact Assessment (5th ed.), Routledge, 2019.
3. Morgan, R.K., Environmental Impact Assessment – A Methodological Approach, Springer, 1999.
4. All guidelines and notifications of Government of India related to EIA rules.
5. Rathi, A.K.A., Handbook of Environmental Impact Assessment: Concepts and Practice, Cambridge Scholars Publishing (9 February 2022)

C-20P:Practical

1. Visit to water treatment, waste water treatment and sewage treatment plants.
2. Digitalization of landslides and flood sensitive zone of Northeast India
3. Preparation of master plan for any Environmental Hazard mitigation

C-21T: ECOLOGY AND ECOSYSTEMS

Unit 1: Ecology of individuals, populations and communities

Basic concepts and definitions of ecology; Major biomes of world; Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; Phenotypic plasticity; Ecotypes; Ecoclines; Concept of ecological niche; Adaptation in plants and animals; Concept of population; r- and K-selection; Characteristics of population; Population growth; Limits to population growth; deterministic and stochastic models of population dynamics; Community structure and organization; Community interactions; Ecological succession.

Unit 2: Ecosystem ecology

Types of ecosystem: Terrestrial, aquatic, marine and wetlands; Ecosystem structure and function; Ecosystem metabolism; Productivity; Models of energy flow; Trophic efficiency; Ecosystem connections; detritus pathway of energy flow and decomposition processes; Ecological efficiencies; Ecological pyramids.

Unit 3: Biogeochemical cycles and Biological invasions

Basic concepts and definitions of nutrient recycling; Major biogeochemical cycles; Ecosystem input and output of nutrients; Ecosystem losses; Biotic accumulation; Decomposition and nutrient release; Nutrient use efficiency; Nutrient budget; Nutrient conservation strategies.

Concept of exotic and invasive species; Dissemination factors of invasive species; Characteristics of invaders; Stages and mechanisms of invasion; Invasive pathways; Impacts of invasion on ecosystem; Economic costs of biological invasions.

Suggested Readings

1. Groom. B. and Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., and Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.

3. Loreau, M. and Inchausti, P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M. and Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist 203: 697-703.
6. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.
7. Singh, J.S., Singh, S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. Bio Science 35: 700-706

C-21P: Practical

1. Identification and enumeration of phytoplankton/zooplanktons in water body.
2. Estimation of primary productivity of a pond/lake.
3. Estimation of standing crop (biomass) of phytoplankton in aquatic system.
4. Estimation of standing crop and productivity in grassland habitat.
5. Estimation of growth, productivity and characteristics of terrestrial plants.
6. Productivity and biomass estimation of litter fauna.
7. Estimation of chlorophyll in terrestrial plants and phytoplankton.
8. Study of Ecological adaptations–
    a) Hydrophytes and xerophytes and
    b) Rocky shore and sandy shore fauna
9. Determination of primary production as GPP and NPP by light and dark bottle technique.
10. Profile study of natural pond/lake and manmade reservoir.
11. To study the cover and based area study of tree species
12. To study the light intensity by sunshine record
13. Determination of relative density relative frequency and relative abundance of species by using simulation.

C-22T: ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

Unit 1: Air and water pollution

Definition of pollution, pollutants and contaminants, Classification of pollutants, Ambient air quality, NAAQS, Air quality index, Sources, types and effects of air pollution, Effects of different air pollutants on human health, Air pollution control measures, Indoor air pollution, Sources types and effects of water pollution, DO, BOD, COD, Water quality standards, Heavy metals and pesticides in water, Emerging water pollutants, WQI, Eutrophication, Effect of water pollution on human health, Water borne diseases.

Unit 2: Soil, Noise pollution, Radioactive, thermal and marine pollution

Causes, effects and control of soil pollution, Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, Physical and mental health, Control measures, Sources of

radioactive pollution, Somatic and genetic effects of radioactive pollution, Thermal pollution and its effects, Sources, effects and control measures of marine pollution, Oil spill, Coral reefs.

Unit 3: Pollutant behavior, pollution control technologies and policy

Transportation, Transformation and Fate of pollutants, Hydrophilic and lipophilic pollutants, Role of chelating agents in transferring pollutants, Biotransformation and bioaccumulation, Radioactive decay and half-life of pollutants, Organometallic compounds, Acid mine drainage, Waste water treatment technologies for domestic and industrial effluents, Zero Liquid discharge, Bioscrubbers, Cleaner fuels, Biofuels, Biodiesel, Air pollution control technologies for vehicular and industrial emission, Regulatory framework for pollution monitoring and control, Ganga and Yamuna action Plan.

Suggested Readings

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

C-22P**: Practical**

1. Estimation of Dissolved Oxygen, Biochemical Oxygen Demand and Chemical Oxygen Demand in water sample.
2. Collection techniques and sampling devices for gaseous pollutants
3. Determination at carbon dioxide from air by using Lungs Zincondroff apparatus.
4. Determination of NOx in ambient air by high volume sampler (HVS).
5. Measurement of Sox by high volume sampler (HVS).
6. Measurement of SPM by using high volume sampler (HVS).
7. Measurement of RSPM by using Respirable Dust Sampler.
8. Determination of atmospheric lead and other metals by using impinger techniques and AAS.
9. Determination of polynuclear aromatic hydrocarbon from air.
10. Study of the effect of heavy metal concentration on seed germination
11. Cytological study of nano toxins on onion root tips

12. Study of rate of uptake of metal toxins by different species of plants.
13. Study of Chlorosis and Necrosis in plant species

C-23T: REMOTE SENSING AND ITS APPLICATIONS

Unit-1: Principles of Remote Sensing:

Concepts of Remote Sensing; Different types of resolution: spatial, radiometric, spectral and temporal, types of sensor; Satellites and their sensors; Data products; Applications of remote sensing in environmental monitoring and management.

Unit-2: Digital Image Processing & Image interpretation:

Principles, Image rectification, Image enhancement and mosaicing; Image classification-Supervised, Unsupervised, Ground truth data and training set manipulation; Classification accuracy assessment; Elements of image interpretation, interpretation keys.

Unit-3: Geographical Information System (GIS)

Basic principles; Raster and vector data; Map projection; Topology creation; Overlay analysis; Data structure and Digital cartography; Applications of GIS and GPS in environmental management.

Suggested Readings

1. Jensen, J.R., Remote Sensing of the Environment-An earth resource perspective (2^{nd} ed.), Pearson Education, India, 2013.
2. Chipman, J.W., Kiefer, R.W., Lillesand, T.M., Remote sensing and Image interpretation, Wiley, 2011.
3. Burrough, P.A., Mcdonell, R.A., Lloyd, C.D., Principles of Geographical Information System (International 3^{rd} ed.), Oxford University Press, U.K., 2016.
4. Hofmann-Wellenhof, B., Lichtenegger, H., Collins, J., Global Positioning System: Theory and Practice, Springer-Verlag, 1997.
5. 5. Joshi, D.C. Remote Sensing and GIS Applications: A Starter Guide, Scientific Publisher, India, 2019.

C-23P: Practical

1. Familiarization of Remote Sensing and GIS Techniques
2. To familiarize with Modules of ESRI ArcGIS software.
3. To understand basics of georeferencing and define projection of a given image
4. To digitize features from a given landuse in ArcMap