

COURSES OF STUDIES **UNDER GRADUATE** **ENVIRONMENTAL** **SCIENCE**

AS PER NEP-2020



ADMISSION BATCH-2024

DEPARTMENT OF ENVIRONMENTAL SCIENCE
S.C.S. (AUTONOMOUS) COLLEGE
PURI
ODISHA-752001

www.scscollege.nic.in

ENVIRONMENTAL SCIENCE

Student graduating with a Bachelor of Science degree in Environmental Science will have demonstrated an ability to:

- Acquired fundamental knowledge of different aspects of environment and local, regional and global environmental problems.
- Understand the basic concepts of Environment and its components along with their interactions through study of Ecology, Biodiversity and Environmental Chemistry.
- Understand different technologies like biotechnology, water and Wastewater treatment technology to find the solutions and their applications in abatement of Pollution and other environmental problems.
- Use of different tools for the management of Environment, Energy resources, solid wastes, Biodiversity conservation like Remote Sensing & Geographical Information Systems and different methodologies.
- Acquired skill and the knowledge to conduct experiments and data analysis needed for the environmental design and management.

Model Curriculum for Three/Four Year Degree Course

(With Multiple Entry /Exit Option)

Based on NEP-2020

Environmental Science



Odisha State Higher Education Council, Bhubaneswar

Government of Odisha

Semester	Subjects
I	Core I - Introduction to Environmental Science
	Core II- Fundamentals of Earth System Science
II	Core III- Natural Resource Conflicts and Management
	Core IV - Fundamentals of Environmental Physics & Chemistry
III	Core V- Fundamentals of Ecosystem Ecology
	Core VI- Climate Change and Disaster Management
	Core VII- Environmental Education
IV	Core VIII - Environmental Pollution and Health
	Core IX- Environmental Challenges and Sustainable Development
	Core X- Environmental Movements and Peoples' Participation
V	Core XI- Waste Management and Alternate Energy
	Core XII- Biodiversity Conservation
	Core XIII- Fundamentals of Remote Sensing and GIS
VI	Core XIV- Environmental Impact Assessment and Management
	Core XV- Environmental Legislation and Policy
VII	Core XVI- Atmospheric Processes and Chemistry
	Core XVII- Limnology
	Core XVIII- Soil Pollution and Management
	Core XIX- Computational Methods in Environmental Science
VIII	Core XX- Research Methodology & Ethics
	Core XXI- Industrial Pollution Control and Management
	Core XXII- Environmental Toxicology
	Core XXIII- Environmental Geosciences and Mining

Programme Outcome

- To prepare the students for a career in Environmental Science.
- To prepare the students for Higher Education and Research in Environmental Science.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To generally promote wider reading on the subject and allied inter disciplinary subject.

Introduction to Environmental Science**Course Outcomes:**

This course builds on the conceptual understanding of students on basic principles behind various environmental processes, with the following outcomes.

- Identify major environmental issues and their historical context.
- Assess the ethical implications of different environmental policies and practices.
- Analyze data related to environmental issues and draw conclusions about trends and patterns.
- Assess the economic, social, and environmental trade-offs associated with various environmental decisions.

Unit 1:

Definition, Concept and Scope of ecology and environmental science. Interactions between Earth, man and environment. Global environmental issues and challenges, Environmental Pollution, Bio-geographic provinces of the world, Concept of sustainable development.

Unit 2:

Concepts of diffusion and dispersion, concept of heat transfer, conduction, convection; concept of temperature, lapse rate, GHGs and global warming, Climate Change: Natural and anthropogenic causes, Pre-industrial era and atmospheric CO₂.

Unit 3:

International treaties and conventions on environmental protection, Convention on biodiversity, environmental movements, environmental laws, constitutional provision, fate of climate dynamics on human health, environmental policies and politics.

Unit 4:

Structure and composition of Atmosphere, Lithosphere, Hydrosphere and Biosphere; Biogeochemical cycles: nitrogen, potassium, phosphorus and Sulphur, Physico-chemical properties of water, Water pollution; Soil formation, composition, Soil degradation.

Practical/Assignment: Based on the theory.

1. Sampling technique of water
2. Estimation of Turbidity – Nephelometric method or Secchi depth
3. Estimation of Acidity – Alkalimetric method / CO₂ – NaOH titration method
4. Estimation of Alkalinity – Acidimetric method
5. Estimation of Hardness – EDTA Complexometric method
6. Estimation of Chlorides – Argentometric method

7. Estimation of Dissolved Oxygen – Modified Winkler’s method
8. Case study on environmental laws or policies.
9. Analysis of climate change related secondary data.
10. Preparation of charts and tables of various environmental data.
11. Preparation of models representing various environmental issues.
12. Assignment on various environmental pollution episodes or policy implementation.

Text Books:

- ✓ *Cunningham, W. and Cunningham, M.A. (2010). Principles of Environmental Science. McGraw-Hill Higher Education.*
- ✓ *Masters, G.M. and Ela, W.P. (1991). Introduction to Environmental Engineering and Science (Vol. 3). Englewood Cliffs, NJ: Prentice Hall.*
- ✓ *Manahan, S.E. (2000). Environmental Chemistry 7th Edn. Lewis Publishers.*

Reference Books:

- ✓ *Beard, J.M. 2013. Environmental Chemistry in Society (2nd edition). CRC Press.*
- ✓ *Boeker, E. & Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.*
- ✓ *Connell, D.W. 2005. Basic Concepts of Environmental Chemistry (2nd edition). CRC Press.*
- ✓ *Girard, J. 2013. Principles of Environmental Chemistry (3rd edition). Jones & Bartlett.*
- ✓ *Harnung, S.E. & Johns on, M.S. 2012. Chemistry and the Environment. Cambridge University Press.*
- ✓ *Hites, R.A. 2012. Elements of Environmental Chemistry (2nd edition). Wiley & Sons.*
- ✓ *Manhan, S.E. 2000. Fundamentals of Environmental Chemistry. CRC Press.*

Core II

Fundamentals of Earth System Science

Course Outcomes:

Understand the various earth process and associated changes in various parameter in ocean and atmosphere. This will help the student's understanding on physical, biological and chemical aspect of ocean in changing climate. This course aims to make students aware of various earth process and its impact on meteorology phenomenon and physical/biological/chemical changes in ocean.

Unit 1: Earth & Earth Processes

Evolution of the solar system, Origin of Earth, Earth's orbital parameters, Kepler's laws of planetary motion; Geological Time Scale, Internal Structure of earth. Plate tectonics: plate boundaries.

Unit 2: Basics of Meteorology

Incoming solar radiations, Heat transfer in atmosphere, radiation of earth, Heat Budget, stability of atmosphere, inversion, formation and types of clouds.

Unit 3: Physical Oceanography

Morphology of ocean floor, types and distribution of marine sediments. Physical and chemical properties of seawater, salinity, Temperature and density variation in ocean, Carbonate buffering system. Global atmospheric circulation and Ocean currents.

Unit 4: Biological and Chemical Oceanography

Classification of marine environment and organisms, physico-chemical factors affecting marine life, ocean productivity, energy flow. Composition of sea water, classification of elements (major and minor), residence time

Practical/Assignment:

Based on the theory – to study the models and understand the earth processes..

Text Book

- ✓ McBride N and Gilmour I (Eds.) (2004). *An Introduction to the Solar System*. Cambridge, UK: Cambridge University Press.
- ✓ Lal DS (1986). *Climatology*, Chaitanya Publication, Allahabad.
- ✓ Summerfield M.A (2011). *Geomorphology and Global Tectonics*, Wiley India Pvt Ltd.
- ✓ Marshall. John, and R. Alan Plumb. *Atmosphere, Ocean, and Climate Dynamics: An Introductory*, Academic Press.

- ✓ *Randall DA (2005). An Introduction to the General Circulation of the Atmosphere, Colorado State University Press.*
- ✓ *Wallace and Hobbs. Atmospheric Science (Latest Edition), An Introductory Survey, Elsevier*
- ✓ *Siddhardha K (2016). The Earth's Dynamic Surface - A book of Geomorphology, Kitab Mahal.*

Natural Resource Conflicts and Management

Course Outcomes:

This course focuses on understanding natural resources management and associated conflicts, if any. The limitation of various approaches related to natural resource management theories and practices.

Unit 1:

Defining relevant concepts: Natural resources, resistance, and natural stuffs; Traditional theories and functional theories of conceptualizing natural resources; Resource Processes and Classification, Resource Scarcity: Conceptualising Resource Scarcity, Indicators of Resource Scarcity

Unit 2:

The Nature of Natural Resources Conflict, Classification, Factors Responsible, and Trend, Analysing the Conflict or Situation, Case studies of Environmental Conflicts, success and failure of collaboration attempts in India and Abroad

Unit 3: Natural Resource Management

Establishing the rationale for NRM: Introducing concepts of Carrying capacity, Ecological Foot-print, Resilience, and Sustainability

Unit 4: Natural Resource Management: Theories and Practices

Approaches in Natural Resource Management: Top-Down Approach, Holistic approach, Integrated approach, Ecosystem Approach, Socio-ecological Approach, Bioregionalism, Decentralized approach

Practical/Assignment: Based on the theory.

Text Book

- ✓ *Ascher, William. (1999) Why Governments Waste Natural Resources: Policy Failures in Developing Countries. Baltimore: The John Hopkins Univ. Press.*
- ✓ *Auty, Richard M. (2001) Resource Abundance and Economic Development. Oxford: Oxford University Press.*
- ✓ *Bridge, G. 2008. Global Production Networks and the Extractive Sector: Governing Resource Based Development. Journal of Economic Geography (8): 389-419.*

- ✓ Bryant, R. & Bailey, S. (1997). *Third world political ecology*. London: Routledge.
- ✓ Hardin, G. (1968): *The Tragedy of the Commons: The population problem has no technical solution; it requires a fundamental extension in morality*. *Science*. 162: 1243-1248.
- ✓ Johnston, R. J. (1996). *Nature, State, and Economy: A political economy of the environment*. Chichester: John Wiley.
- ✓ Leopold, A. (1949). *A Sand County Almanac: With Essays on Conservation*. New York: Oxford University.
- ✓ Malthus, T. R. (1798). *An essay on the principle of population*. London. J. Johnson.
- ✓ Neumann, R.P. (2005). *Making political ecology*. London: Hodder Arnold
- ✓ Ostrom, E. (1990). *Governing the commons: The evolution of institution for collective action*. Cambridge: Cambridge University Press.
- ✓ Pepper D. (1993). *Ecosocialism: From deep ecology to social justice*. London: Routledge.
- ✓ Conover, M. 2001. *Resolving Human Wildlife Conflicts*, CRC Press.
- ✓ Dickman, A. J. 2010. *Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict*. *Animal Conservation* 13: 458- 466.
- Messmer, T. A. 2000. *The emergence of human–wildlife conflict management: Turning challenges into opportunities*. *International Biodeterioration & Biodegradation* 45: 97- 102.

Core IV

Fundamentals of Environmental Physics & Chemistry

Course Outcomes:

The basic law will help student to understand the atmosphere and environment and chemistry of water, air and soil science. The main objective is to understand the basic concept of fundamental of environmental physics and chemistry behind the environmental changes and issues.

Unit 1: Fundamentals of environmental physics

Basic concepts of light and matter, black body radiation, Kirchhoff's law, Stephan-Boltzmann equation, Wein's Displacement law, absorption and transmission of light, Beer-Lambert law. Scattering of light: Rayleigh and Mie scattering, Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force).

Unit 2: Pollutants in the environment

Concepts of diffusion and dispersion, Concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); mixing heights, Wind circulation, transport, dispersion, and deposition.

Unit 3: Fundamentals of environmental chemistry

Stoichiometry, Gibb's energy, Chemical potential, chemical equilibria, chemical kinetics, acid-base theories and salts, concepts of pH and pE, concept of buffer, Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, xenobiotic compounds like pesticides and dyes, synthetic polymers, Unsaturated and saturated hydrocarbons, Radioisotopes.

Unit 4: Air, Water and Soil chemistry

Structure and composition of atmosphere; photochemical reactions in atmosphere; smog and fog, aerosols, acid rain, ozone chemistry and ozone layer depletion. Physicochemical properties of water; alkalinity and acidity of water, hardness of water, solubility of gases in water, Soil composition. relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation exchange reactions in soil; NPK in soil.

Practical/Assignment: Based on the theory.

Text Books:

- ✓ *Fundamentals of Environmental Chemistry* by Stanley E. Manahan
- ✓ *Fundamentals of Physics and Chemistry of the Atmosphere* by Guido Visconti
- ✓ *Fundamental Principles of Environmental Physics* by Abel Rodrigues , Raul Albuquerque Sardinha , Gabriel Pita.

Core V

Semester III

Fundamentals of Ecosystem Ecology

Course Outcomes: To gain an understanding of (1) complex processes in population and community ecology (2) population growth and dynamics and its regulation (3) Recognise the importance of ecological interactions in shaping the structure of ecological communities. Strengthen the understanding of community ecology and population. The course will enlighten the fundamentals of community structure and organization.

Unit 1: Introduction

Aim and scope of ecology, biological levels of organization- genes to biosphere, Human dimensions in ecology, Population ecology: Population and metapopulation, Demographic parameters - Mortality, fecundity and age structure. Life tables – cohorts and static. Population growth: exponential and logistic. Population growth and Regulation, logistic model of population growth, Lotka- Volterra model.

Unit 2: Population and Community Structure and Organization

Nature of community and continuum, Biotic interactions: Competition, mutualism, parasitism, prey-predator relations, Ecological niche, keystone species, Umbrella species, ecological diversity, Ecological succession, Natural and anthropogenic disturbances of ecosystem, Invasive species: impacts and control.

Unit 3: Ecosystem components and processes- Photosynthesis and decomposition, Global C and N cycle, Man's impact on nutrient cycle, Energy in Ecological systems: energy transformations, global distribution of primary productivity.

Unit 4: Ecosystem Regulation- Ecosystem stability, Regulation, Analytical models in Ecology: Models of succession. Ecological sustainability, Ecological footprint, carbon footprint, water footprint.

Practical/Assignment: Based on the theory.

1. Analyze the population structure of tree species in a given area.
2. Analyze the vegetation by quadrat method
3. Biodiversity assessment of forest tree community
4. Nutrients cycling in forest: Soil sampling & Organic carbon analysis.
5. Belowground vegetation: Find root biomass determination.
6. Quantification of forest standing stock of litter and carbon analysis.
7. Assessment of forest disturbance for conservation aspects

Texts Books/References:

- ✓ *E.P. Odum (1996) Fundamentals of Ecology, Nataraj Publisher. Dehra Dun.*
- ✓ *M.C. Dash (1994) Fundamentals of Ecology, Tata McGraw Hill. New Delhi.*
- ✓ *M.C. Mollesh Jr. (1999) Ecology-Concepts and Application, McGraw Hill, New Delhi.*
- ✓ *V. Ingegnoli (2002) Landscape Ecology: a widening foundation, Springer, Bonn.*
- ✓ *E.J. Korondi (1999) Concept of Ecology, Prentice Hall of India, New Delhi.*
- ✓ *Chapman, J.L. and Reiss M.J. (2005) Ecology Principles And Applications, Cambridge University Press, London.*
- ✓ *E.P. Odum and G.W. Barrett (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd., Singapore.*
- ✓ *S.V. Rana (2005) Essential of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi. 11. Environment And Ecology-EAS105/EAS 205-R.Radagopalan.*

Core VI

Climate Change and Disaster Management

Course Outcomes: To understand various types of natural disaster and associated risk during and aftermath. This course also has covered the various disaster preparedness and response mechanism to minimize the impact and also discuss the couple of major disasters occurred in India. The outcome will be helpful for student to understand the vulnerability of various disasters and required preparedness and respond action. The paper also covers national policy and act being adopted to manage disaster in the country.

Unit 1: Introduction to Disasters:

- Concepts and Scope of Disaster Studies. Defining Hazard and Disaster and their Classification
- Natural Disaster: Geological Disasters, Hydro-Meteorological Disasters, Biological Disasters,
Manmade Disaster: Fire, Nuclear, radiological, chemicals and biological disasters.

Unit 2: Risk Assessment and Vulnerability Analysis

Risk Concepts, Elements of Risk, Perception of Risk, Acceptable risk, Requirements in Risk assessment, Strategies of Risk reduction, Concept, Observation and perception of vulnerability- Vulnerability Identification, Factor of Vulnerability, Vulnerability types and dimension, Vulnerability Reduction. Disaster risk resilience.

Unit 3: Disaster Preparedness and Response

Disaster Preparedness: concept and significance, and Disaster Preparedness Measures, Concept and Significance of Disaster Preparedness Plan, Prediction, Early Warnings and Safety Measures for Disaster.

Unit 4: Disaster management in India

Disaster Profile of India – Mega Disasters of India and Lessons Learnt, Disaster Management Act 2005 – Institutional and Financial Mechanism, National Policy on Disaster Management,

Practicals/Assignment/Project: Based on the theory.

Suggested Readings

- ✓ *Environmental Hazards by Smith, K., Routledge, London, 1992.*
- ✓ *Geological Hazards by Bell, F.G., Routledge, London, 1999.*

Reference books

- ✓ *Principles of Engineering Geology by Krynine, D.S. and Judd, W.R., CBS, New Delhi, 1998.*
- ✓ *Natural Hazards by Bryant, E., Cambridge University Press. London, 1985.*
- ✓ *Landslide Disaster – Assessment and Monitoring Nagarajan, R., Anmol Publications, New Delhi, 2001.*
- ✓ *Environmental risks and hazards by Cutter, Susan L., Prentice Hall of India, New Delhi. 1999.*
- ✓ *Bill McJuire, Ian Mason and C. Killburn (2002) Natural hazards and Environmental change, Oxford University Press, New York.*
- ✓ *Gupta, Harsh K. (2003) Disaster Management, Universities Press (India) Pvt. Ltd*
- ✓ *Coppola, Damon P. (2006) Introduction to International Disaster Management*

Core VII

Environmental Education

Course Outcomes:

Understanding on the basics of environmental education and ethics, environmental conservation movements and environmental protection and conservation.

Unit I

Environmental education: Background and definition, Methods of EE- Formal and Non-formal education, Goals and objectives of Environmental education; International norms guiding EE, Current scenario of EE in India and the world, Major challenges and the possible way-outs.

Unit II

Environmental ethics – concept, Eco-philosophy: eco-centric and anthropocentric world views, Environmental ethics and sustainable development; Ethical principles in moral reasoning about the environment; Imbibing lessons from religions, cultures and human values, Relevance of Environmental ethics in the present-day society.

Unit III

Environmental Awareness: definitions and concepts, role of Government, NGOs and media; People's initiatives to save the environment in the western world; Gandhian, Marxism and Indian environmentalism; Environment awareness programme in Northeast India with special emphasis on Mizoram.

Unit IV

Global and National environmental Organizations and agencies; UNEP, MAB, IUCN, UNFCCC (COP); Environmental Movements in India- Chipko movement; Silent Valley project movement; Appiko movement; Narmada Bacchao Andolan movement; Tehri Dam Movement. Initiatives for Environment Conservation in India- government initiative, institutional initiative, role of voluntary organizations in environmental conservation, initiatives taken by educational institutions, green warriors.

Practical/Assignment: Based on the theory.

Suggested Readings:

- ✓ *Senapati, T. and Sahoo, R.K. (2009). Environmental Education and Pollution Control, Mittal Publications, Daryaganj, New Delhi.*
- ✓ *Vromans, K. et al., 2012. Environmental Ethics- An Introduction and Learning Guide. Atlantic Publishers and distributors.*
- ✓ *Kothari Dr. Milind, 2005. Environmental Education – Universal Publication, Agra.*
- ✓ *Thaddeus C. et al., 2001. World Directory of Environmental Organizations. International Center for the Environment and Public Policy, California Institute of Public Affairs.*
- ✓ *Sahgal, A., 2010. CCE Awareness Environmental Studies-5. S. Chand Publishing*
- ✓ *Bharucha, E. 2015. Text Book of Environmental Studies. University Press (India) Pvt. Ltd., Hyderabad.*
- ✓ *Vij J. Nornam and Axelrod. 1999. The Global Environment, Institutions, Law and Policy, Earthscan Publishers Ltd, UK.*
- ✓ *Mishra, S. 2010. Green Warriors: conserving Local Biodiversity through Community Conservation Initiatives in Orissa, India. Policy Matters, 17, 143-149.*

Core VIII

Semester IV

Environmental Pollution and Health

Course Outcomes:

To understand the health issues related to pollution due to various environmental pollutants. To understand and Implement pollution prevention strategies and control measures. To assess the ecological and human health impacts of specific pollutants, considering short-term and long-term consequences.

Unit-1: Air pollutants and Health:

Ambient Air Quality: monitoring and standards; air quality index; effects of different pollutants on human health and control measures; indoor air pollution: sources and effects on human health; Air borne disease: causes, symptoms, and preventive measures.

Unit-2 : Water pollution and health:

Sources of surface and ground water pollution; water quality parameters and standards. Organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); classification of pollutants; solubility of pollutants (hydrophilic and lipophilic pollutants), water borne disease: causes, symptoms, and preventive measures. Public awareness of sanitation and hygiene issues.

Unit-3: Soil pollution and impact:

Sources and properties of soil pollutants (Synthetic fertilizers, pesticides, polythene, Organometallic compounds, Heavy metals); impacts of these pollutants on human health. Soil quality standards. Soil composition. inorganic and organic components in soil; soil humus.

Unit-4: Noise pollution and health:

Sources of noise and permissible noise levels; effect on communication, impacts on life forms and humans, control measures; Noise induced hearing loss. Radiation pollution and human health: Effects of Radioactive pollution.

Practical: Based on the theory.

1. Test of solubility of substances
2. Preparation of standard solution
3. Test for serial dilution of a concentrated solution
4. Test of microbial count present in soil
5. Test for microbial count present in water
6. Test for microbial count present in open air
7. Determination of dissolve oxygen content of water
8. Determination of BOD of water
9. Determination of COD of water

Text Book/Suggested readings.

- ✓ *Rana, S.V.S. 2011. Environmental Pollution: Health and Toxicology. Alpha Science International Ltd; 2nd revised edition.*
- ✓ *Joshi, B.D., Joshi, P.C., & Joshi, Namita. 2008. Environmental Pollution & Toxicology. APH Publishing Corporation, New Delhi.*
- ✓ *Santra, S.C. 2017. Environmental Science. New Central Book Agency (P) Ltd., Kolkata.*
- ✓ *Anjaneyulu and Narasimha, R. 2009. Introduction to Environmental Science. B.S. Publications, Hyderabad.*
- ✓ *Katyal, T. and Satake, M. 2005. Environmental Pollution. Anmol Publication, New Delhi.*
- ✓ *Kannan, K. 2006. Fundamentals of Environmental Pollution. S. Chand and Company, New Delhi.*
- ✓ *Trivedi, R.K. and Goel, P.K. 1984. Chemical and Biological Methods of Water Pollution Studies. Enviro Media, Karad (India).*

- ✓ *Gupta, P.K. 2011. Methods in Environmental Analysis: Water, Soil, Air (2nd Edition). Vatsal Enterprises, New Delhi.*
- ✓ *Fundamentals of Environmental Chemistry by Stanley E. Manahan*
- ✓ *Fundamentals of Physics and Chemistry of the Atmosphere by Guido Visconti*

Core IX

Environmental Challenges and Sustainable Development

Course Outcomes: Understanding the human population growth pattern and its associated environmental impacts. To examine the principles and practices of sustainable agriculture and their role in ensuring global food security. To understand the utility of sustainable farming methods, and strategies to address food insecurity. The student will have the theoretical knowledge with practical applications to promote critical thinking and problem-solving skills.

Unit 1: Demographic Overview

Introduction, History of human population growth, The demographic transition: India and World; Projections of population growth, Effects of human population growth, Unsustainable lifestyle – increased consumerism.

Unit 2: Sustainable Agriculture

Definition and principles of sustainable, Importance of sustainable practices in modern agriculture; sustainable farming methods agriculture Challenges to global food security;

sustainable agricultural policies and regulations; Concept of modern agriculture, impacts of modern agriculture on environment; Sustainable soil management practices. Concept of green technologies; role of green technologies towards a sustainable future.

Unit 3: Environmental Contamination

Ambient Air pollution, Surface water pollution, Ground water pollution and Health Impacts, Solid Waste Pollution and Sustainable Solid Waste Management; Hazardous waste pollution, Radioactive waste, electronic waste and Biomedical waste, Impact of pesticides and fertilizers on ecosystem; Sustainable soil management practices.

Unit 4: Ecological Footprints and Carrying Capacity

Ecological footprints: Concepts, perspectives, carbon footprint, water footprint, Overshoot of ecological footprint and biocapacity of planet Earth, Resources Depletion.

Projects/assignments/ case studies:

1. Analyze current government policies related to agriculture and food security.
2. Compare traditional farming methods with modern sustainable practices.
3. Choose a region or country facing food security challenges. Analyze the root causes, current initiatives, and propose sustainable solutions to address the food security issues
4. Research and present case studies of successful organic farms. Analyze the key factors contributing to their success
5. Case studies of Community Supported Agriculture programs. Assess their impact on local communities, farmer livelihoods, and sustainable food production.

Text Books

- ✓ *Cunningham WP and Cunningham MA (2002). Principles of Environmental Science: Inquiry and Applications. McGraw-Hill Publications, New Delhi, 418 pp.*
- ✓ *Johri R (2009). E-Waste: Implications, regulations, and management in India and current global best practices. TERI Press, New Delhi. 330 pp.*
- ✓ *McKillop A and Newman S (2005). The Final Energy Crisis. Pluto Press, London. 325 pp.*
- ✓ *Miller GT Jr. (1996). Living in The Environment: Principles, Connections, and Solutions. 9th Edition. Wadsworth Publishing Company, New York. 727 pp.*
- ✓ *Park C (2001). The Environment: Principles and Applications. 2nd Edition, Routledge Publishers, London and New York, 598 pp.*

Reference Books

- ✓ Galli A (2010). *Stomping on biodiversity: humanity's growing Ecological Footprint*. In: *Commonwealth Ministers Reference Book*. Pp. 156-159.
- ✓ McKinney ML and Schoch RM (1998). *Environmental Science: Systems and Solutions*. Jones and Bartlett Publishers, Boston. 639 pp.
- ✓ MoEF (2009). *State of Environment Report, India – 2009*. Ministry of Environment and Forests, New Delhi
- ✓ Sengupta B (2000). *Environmental standards for ambient air, automobiles, fuels, industries and noise*. Central Pollution Control Board, New Delhi, India. 78 pp.
- ✓ WHO (2006). *World Health Report 2006*, World Health Organization, Geneva.
- ✓ Popkova, E., Kovaleva, M., Filho., W.L., 2022. *Sustainable Agriculture and Food Security*. Springer Cham. <https://doi.org/10.1007/978-3-030-98617>
- ✓ Shiva, V. & Bedi, G. 2002. *Sustainable Agriculture and Food Security: The Impact of Globalization*. SAGE Publications

Core X

Environmental Movements and Peoples' Participation

Course Outcomes:

To understand different environmental movements in Human history and during the contemporary world with case studies on people's participation on conservation of natural resources and protection of ecosystems.

Unit 1: Introduction to Environmental movements

History of environmentalism in Europe and the United States from the late 19th century until now.

Unit 2: Theories of Environmental Movement

Theories on and approaches to Environmental movements, Romanticism, Silent Spring, Population Bomb and Limits to Growth

Unit 3: Contemporary environmental movements

Drivers of environmentalism in Third World Countries, Evaluate the approaches applied by environmental movements from the perspective of their efficacy.

Unit 4: Environmental Movement in India

Case studies of environmental movements in India: Appiko Movement, Chipko Movement, Narmada Bachhao Andolan; corporate responsibility movement; appropriate technology movement; environmental groups and movements, citizen groups; role played by NGOs; environmental education and awareness

Text Books:

- ✓ Ehrlich, P. E. (1968). *The Population Bomb*. Ballantine Books, 11-69.
- ✓ Meadows, D. H, Meadows, D. L., Randers, J., Behrens III, W.W. (1972). *The Limits to Growth. A Report for the Club of Rome's project on the Predicaments of Mankind*. A Potomac Associates Book, 17-24.
- ✓ LaRouche Jr., L. H. (1983). *There are No Limits to Growth*. New Benjamin Franklin House, 1- 12.
- ✓ Pierson, P. (2004). *Politics in Time. History, Institutions, and Social Analysis*. Princeton University Press, 17- 53.
- ✓ Engler, M. &Engler, P. (2017). *This is an Uprising. How nonviolent revolt is shaping the twenty-first century*. Nation Books, xi-xxii
- ✓ Engler, M. &Engler, P. (2017). *This is an Uprising. How Nonviolent Revolt is Shaping the Twenty-first Century*. Nation Books, 31-58. Alinsky, S. (1971). *Rules for Radicals*.
Vintage Books Edition, 24-48. Piven, F. F. &Cloward, R. A. (1979). *Poor People's Movements. Why They Succeed, How They Fail*. Vintage Book Edition, 1-37.
- ✓ Stoll, S. (2007). *The Rise of US Environmentalism*. In S. Stoll (Ed.), *US Environmentalism since 1945. A Brief History with Documents*. Palgrave, 1-26.
- ✓ Muir, J. (Ed.). (1912). *Hetch Hetchy*. In *The Yosemite*, The Century Company, 1-4.
- ✓ Carson, R. (2007). "Silent Spring, 1962" In S. Stoll (Ed.), *US Environmentalism since 1945. A Brief History with Documents*. Palgrave, 76-82.
- ✓ Guha, R. 1989. *Ecological change and peasant resistance in the Himalaya*. Unquiet Woods, Oxford University Press, Delhi.
- ✓ Leopold, A. 1949. *The Land Ethic*. pp. 201-214. Chicago, USA.

- ✓ *National Research Council (NRC). 1996. Linking Science and Technology to Society's Environmental Goals. National Academy Press.*
- ✓ *Pandit, M.K. 2013. Chipko: Failure of a Successful Conservation Movement. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 126- 127. Wiley-Blackwell, Oxford, UK*

Core XI

Semester V

Waste Management and Alternate Energy

Course Outcomes

- Understanding on characteristics and types of waste and their environmental impacts
- Understanding on liquid waste management and treatment options
- Understanding on various alternate energy resources.

Unit 1: Solid Wastes

Types, sources, characteristics, and impact on environmental health. Waste generation rates, Concepts of waste reduction, recycling and reuse. Collection, segregation and transport of solid wastes, Handling and segregation of wastes at source. Collection and storage of municipal solid wastes. Solid waste processing technologies. Composting, Vermicomposting, Incineration of solid wastes.

Unit 4: Liquid Wastes

Waste water composition, waste water treatment plants (types of treatment, treatment technologies and design criteria (Preliminary treatment, primary treatment, secondary treatment, tertiary treatment), effluent discharge standards for various types of industries

Unit 3: Introduction to Alternative Energy Sources

Definition, Concept of alternate energy, Global and national energy scenarios, Energy resource availability, Prospects of alternate energy sources benefits and limitations of alternative sources of energy, Patterns of energy supply, Need of alternate energy sources.

Unit 4: Types of Alternative Sources of Energy

- **Solar Energy:** Solar radiation, flat plate collectors, solar concentration, thermal applications of solar energy, photovoltaic technology and applications, energy storage.
- **Biomass Energy:** Energy from biomass, thermo chemical, biochemical conversion to fuels, biogas and its applications.
- **Wind Energy:** Wind characteristics, resource assessment,
- **HydroPower:**Hydro based electricity generation and energy potential in India , ,
- **Other Alternate Sources:** Ocean thermal energy conversion, Geothermal, Tidal, Wave energy, environmental issues of energy services.

Text Books

- ✓ *J. Glynn Henry and Gary. W. Heinke, “Environmental Science and Engineering”, Prentice Hall of India, 2004.*
- ✓ *A. D.Bhide and B.B.Sundaresan, “Solid Waste Management – Collection, Processing and disposal” Mudrashilpa Offset Printers, Nagpur, 2001.*
- ✓ *Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers (2005).*
- ✓ *Rao, S. and Parulekar, B.B., Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers (2005).*
- ✓ *Simon, Christopher A., Alternate Source of Energy, Rowman and Little Field Publishers Inc. (2007).*
- ✓ *Alternative Energy Sources by Efstathios E. Stathis Michaelides at Springer-Verlag Berlin Heidelberg in 2012, ISBN 978-3-642-20950-5.*

Core XII

Biodiversity Conservation

Course Outcomes: By the end of this course, students should be able to:

- Understand the fundamentals of biodiversity and bio-geographical zones in India, importance, and threats to biodiversity, and conservation measures for biodiversity conservation.
- Describe the causes and consequences of recent changes in biodiversity status.
- Describe current conservation responses to counter-act the loss of biodiversity.
- Explain the origin and distribution of biodiversity, how biodiversity is defined and measured, and how it varies in space and time.
- Evaluate and justify the need for biodiversity, and how its loss impacts human societies.

Unit 1: Introduction to Biodiversity

Definition, Magnitude of biodiversity, Elements and levels of biodiversity, Genetic, Species and Ecosystem diversity, alpha, beta and gamma diversity. Bio-geographical classification of India, India as mega-biodiversity nation

Unit 2: Importance of biodiversity

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

Unit 3: Threats to biodiversity

Factors causing biodiversity loss, extinction of species, 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; human and wildlife conflicts; consequences of biodiversity loss.

Unit 4: Conservation of biodiversity

In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); *ex-situ* conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), IUCN Red List categorization; Red Data book; CBD (Convention on Biological Diversity) and its goals, Man and Biosphere programme of UNESCO, National Biodiversity Action Plan.

Text Books:

- ✓ *Gaston, K.J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.*
- ✓ *Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.*

Reference Books:

- ✓ *Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.*
- ✓ *Pandit, M.K. & Grumbine R.E. 2012. Ongoing and proposed hydropower development in the Himalaya and its impact on terrestrial biodiversity. Conservation Biology 26:1061-1071.*

- ✓ *Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review 53:80-192.*
- ✓ *Singh, J. S., Singh, S.P. & Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.*
- ✓ *Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.*
- ✓ *Sodhi, N.S., Gibson, L. & Raven, P.H. 2013. Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK.*

Core XIII

Fundamentals of Remote Sensing and GIS

Course Objectives: The course is designed to make student know about remote sensing technique to extract information about earth using various sensors and satellite along with basic concept of GIS. Students will get accustomed to new technology and advance approaches to handle environmental data and its application.

Unit 1: Fundamental of Remote Sensing

Definition and Overview of Remote Sensing, History and Evolution of Indian Remote Sensing ,fundamental of Remote Sensing Systems. Energy: Sources of energy, Energy

radiation principle, Electromagnetic Radiation (EMR), Satellite types and platform used, Atmospheric Window, Energy interaction in the atmosphere and earth surface feature.

Unit 2: Remote Sensing Techniques

Basic features of different types of sensors- Active & Passive sensors. Various characteristic feature of sensor, Image, Principles of satellite Remote sensing, data acquisition, Remote Sensing Data Products, Monochromatic and FCC images.

Unit 3: Introduction to GIS

Geographical Information System (GIS), Concept, definition & components. Spatial data and its analysis, Map type, Map Scale, Map Projection, Geo-referencing, Digitization, Ground Control Point (GCP), vector and raster data, Basic analysis using GIS tools, Indian navigation satellite system, GPS satellites.

Unit 4: Applications of RS & GIS

Application and benefits of remote sensing in different fields, biodiversity, coastal zones, flood management, forest/natural resource management, ground water prevention, Ocean, disaster, climate/meteorology and atmospheric science. Current role of geo-informatics on environment and climate science.

Practical/Assignment: Based on the theory.

Text Books:

- ✓ *Textbook of remote sensing and geographical information systems by M. Anji Reddy*
- ✓ *Principles of Geographical Information Systems for Land Resource Assessment — P. A. Burrough.*
- ✓ *Introduction to Remote Sensing, James B. Campbell and Randolph H*

Core XIV

Semester VI

Environmental Impact Assessment and Management

Course Outcomes:

- Understanding on the concept of EIA, the associated processes and notifications.
- Understanding on the EIA methodology, prior environmental clearance process and EMP
- Understanding on the restoration and rehabilitation procedures and policies.

Unit 1:

Introduction to Environmental Impact Assessment. Environmental impact Statement and Environmental Management Plan. EIA notifications of Government of India from time to time. Guidelines for Environmental audit.

Unit 2:

Environmental Impact Assessment (EIA) Methodologies. Generalized approach to impact Assessment. EIA processes, Scoping EIA methodologies, Procedure for reviewing Environmental impact analysis and statement. Environmental Management Plan and its Monitoring, Evaluation of proposed actions.

Unit 3:

Nexus between development and environment, Socio-economic impacts, Aid to decision making, Formulation of development actions, Sustainable development, categorization of projects under EIA, project planning and implementation, Impact prediction, Mitigation measures.

Unit 4:

Introduction to. Selection of appropriate procedures, Restoration and rehabilitation technologies. Land use policy for India. Urban planning for India. Rural planning and land use pattern. Environmental priorities in India and sustainable development. CRZ notifications and Environmental Impact Assessment in coastal zone. Coastal zone management plans of India.

Practical/Assignments: Based on Theory

Text Books:

- ✓ *W.P. Cunningham, 2010: Principles of Environmental Science.*
- ✓ *Satsangi and A. Sharma 2015: Environmental Impact Assessment and Disaster Management.*
- ✓ *R.R. Barthwal 2002: Environmental Impact Assessment.*
- ✓ *C.H.Eccleston, 2004: Environmental Impact Assessment.*
- ✓ *J. Glasson, 2011: Introduction to Environmental Impact Assessment.*
- ✓ *Glasson J., Therivel R., Chadwick A, (2005): Introduction to environmental impact assessment Taylor & Francis Group, London and New York.*
- ✓ *Morris P., Therivel R., (2009): Methods of Environmental Impact Assessment 2009, 3rd edition, Routledge, Taylor & Francis Group, London and New York.*

- ✓ *Morris P., Therivel R., (2001): Methods of Environmental Impact Assessment 2001, 2nd edition, Spon Press, Taylor & Francis Group, London and New York.*
- ✓ *Eccleston C. H., (2011): Environmental Impact Assessment 2011, CRC Press, Taylor & Francis Group.*

Reference Books

- ✓ *J. Hou, 2015: New Urbanism: The future City is Here.*
- ✓ *James R. Craig, 2010: Earth Resources and the Environment.*
- ✓ *R. Paliwal and L. Srivastava, 2014: Policy Intervention Analysis- Environmental Impact Assessment.*

Core XV

Environmental Legislation and Policy

Course Outcomes

- Understanding on various relevant acts and notifications for protection of environment and conservation of natural resources.
- Understanding on different international conventions and treaties for on protection environmental and conservation natural resources.

Unit 1: Guiding Principles of Environmental Law:

The Precautionary Principle, The Prevention Principle, The “Polluter-Pays” principle, The Integration principle, The Public Participation principle

Unit 2: International Legislations, Policies for Environmental Protection:

Salient features of: Stockholm Conference (1972) and its declaration, World Commission on Environment and Development (1983) and Brundtland Report (1987), Rio Earth Summit (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971

Unit 3: National Legislations, Policies for Pollution Management:

Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy -2006, Central and State Pollution Control Boards: Constitution and power.

Unit 4: Public Participation for Environmental Protection:

Environmental movement and people’s participation with special references to Gandhamardan, Chilika and Narmada Bachhao Andolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.

Practical/Assignments: Based on Theory

Text Books:

- ✓ *Environmental Protection and Laws by Jadhav and Bhosale, V.M.Himalaya publ. House*
- ✓ *Doabia TS (2017). Environmental & Pollution Laws in India (Set of 2 Vol). 3rd Edition. LexisNexis. 3496 pp.*
- ✓ *Ghosh S (2019). Indian Environmental Law: Key Concepts and Principles. 1st Edition. The Orient Blackswan. 360 pp.*

Atmospheric Processes and Chemistry

Course Outcomes:

Students will get accustomed to atmospheric chemistry along with interconnected phenomena leading to climate, air quality, ozone issue in atmosphere.

Unit 1: Fundamentals of Earth System and Atmospheric Chemistry:

Structure and composition of the Atmosphere, Hydrosphere, Lithosphere and Biosphere, Evolution of earth's atmosphere, nitrogen, hydrogen, halogen, sulphur, and carbon-containing compounds in the atmosphere, Particles, ions and radicals in the atmosphere, ozone chemistry.

Unit 2: Basic Atmospheric Processes:

Systems and surroundings, Mass and energy transfer across the various systems, Material Balance, laws of thermodynamics, heat transfer process. Meteorological parameters: humidity, mixing ratio, saturation mixing ratio, radiation and wind velocity, adiabatic lapse rate, environmental lapse rate.

Unit 3: Atmospheric Process Chemistry:

Evolution of the ozone layer, sources and sink of the tropospheric and stratospheric ozone, thermochemical and photochemical reactions in the atmosphere, atmospheric aerosols, concentration and size, sources and Chemical processes in the formation of inorganic and organic particulate matters, chemical composition, transport and sinks, atmospheric effects, Photochemical smog.

Unit 4: Fundamentals of Air Pollution and its Effects

Air pollution: gases and particulate matter; Air quality standards; Primary and secondary pollutants; Criteria pollutants, ambient standards, air quality indices, visibility. Greenhouse gases, global warming, climate change, urban heat islands, acid rain, and ozone hole.

Practical/Assignment: Based on the theory.

Text/Reference Books:

- ✓ *Atmospheric Processes: Physical And Basic Sciences by Sunayan Saha*
- ✓ *Introduction to Atmospheric Chemistry: By Daniel J. Jacob*
- ✓ *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change: By John H. Seinfeld and Spyros N. Pandis*

Core XVII

Limnology

Course Outcomes:

Understanding on the physical, chemical and biological structure and associated processes of inland aquatic ecosystems; Familiarization on methods of collecting and studying aquatic samples through hands-on field and laboratory experience.

Unit 1: Introduction to limnology:

Types of inland water bodies, their characteristics (physical, chemical and biological) and distribution; Freshwater ecosystem – lentic water bodies – pond - lakes –types (based on origin, based on thermal stratification); lotic water bodies — streams-springs- major Indian rivers – abiotic parameter- biotic communities. Influence of physical and chemical conditions on living organisms in inland waters. Famous lakes of the world and India.

Unit 2: Aquatic flora and fauna:

Planktonic organisms; distribution and food of planktonic organisms; Aquatic plants: characteristics, classification, seasonal variations, distribution in different waters, limnological role. Nekton: composition, distribution, movements. Benthos: classification; periphyton; zonation; distribution; movements and migration; seasonal changes in benthos, profundal bottom fauna.

Unit 3: Biological productivity:

Classification of lakes based on productivity; laws of minimum; biotic potential, circulation of food material; productivity of lotic environments. influence of currents; plant growth; plankton; nekton; benthos; temporary and head waters streams; ecological succession.

Unit 4: Conservation efforts:

Wetland conservation, Ramsar convention, Conservation: exotic species, endangered species, protection, ecosystem services, Climate change and aquatic ecosystems, paleolimnology.

Practical/Field work

- a. Determination of physical and chemical characteristics of lentic water bodies.
- b. Determination of physical and chemical characteristics of lotic water bodies.
- c. Collection and identification of fresh water phytoplankton.
- d. biomass estimation of freshwater phytoplankton
- e. Collection and identification of benthos from lakes and ponds, streams and canals.
- f. Collection and identification of nekton/aquatic insects from freshwater bodies.
- g. Collection and identification of aquatic plants from different fresh water bodies.
- h. Field visit to lotic and lentic water bodies.

Text Books:

- ✓ *Dodds WK (2002). Freshwater Ecology: Concepts and Environmental Applications. Academic Press, San Diego, California, USA.*
- ✓ *Maltby E (1986). Waterlogged Wealth. Earthscan, London.*
- ✓ *Mitsch WJ and Gosselink JG (2000). Wetlands. 3rd Edition. John Wiley & Sons, New York.*
- ✓ *Prusty BAK, Chandra R and Azeez PA (2017). Wetland Science: Perspectives from South Asia. 1st Edition. Springer Publishers. ISBN 978-81-322-3715-0*
- ✓ *Wetzel RG (2001). Limnology: Lake and River Ecosystems. Third Edition. Academic Press, San Diego, California, USA. 1006 pp.*

Suggested Readings

- ✓ Gopal B (Compiler) (1995). Handbook of Wetland Management, WWF-India, New Delhi, India. 305 pp.
- ✓ Gopal B, Hillbricht-Ilkowska A and Wetzel RG (1993). Wetlands and Ecotones: Studies on land-water interactions. National Institute of Ecology and International Scientific Publications, New Delhi, India.
- ✓ Gopal B, Turner RE, Wetzel RG and Whigham DF (1982). Wetlands: Ecology and Management. International Scientific Publications and National Institute of Ecology, Jaipur, India.
- ✓ Ramachandra TV, Ahalya N, Rajasekhara Murthy C (2005). Aquatic Ecosystems: Conservation, Restoration and Management. Capital Publishing Company, New Delhi.

Core XVIII

Soil Pollution and Management

Course outcomes:

Understanding on the causes, effects, and management of soil pollution.

- Examination of the impact of human activities on soil quality, learn about soil pollutants, and explore sustainable soil management practices.

Unit 1: Introduction to soil pollution

Understanding soil environment, soil formation processes and its classification, soil degradation, Natural and anthropogenic sources of soil pollution; soil contaminants such as heavy metals, pesticides, fertilizers, industrial chemicals, and organic contaminants; Soil pollution due to mining and mineral extraction, radioisotopes in soil; soil erosion.

Unit 2: Impact of soil pollution on ecosystem and human health

Impact of soil pollution on soil biodiversity, soil microorganisms and plants communities; Health risk associated with contaminated soil, including carcinogenic and non-carcinogenic effects; Bioaccumulation and biomagnifications of organic pollutants in soil; Impact of soil degradation on agriculture and food security; Deforestation and desertification; Role of soil pollution in environmental disaster.

Unit 3: Soil management and Remediation strategies

Preventive measures to reduce soil pollution, Soil remediation techniques (Physical, chemical and biological); Phytoremediation and bioremediation; Soil conservation and sustainable land management, sustainable agricultural practices and land use planning.

Unit 4: Policy and future directions in soil pollution management

Environmental policies and regulations, national and international policies addressing soil pollution, soil pollution Act, soil pollution and its legal control.

Practical

1. Estimation of soil color (munshell soil colour chart), pH and temperature
2. Determining the CEC in different soil samples
3. Determination of water holding capacity in soil
4. Determine total moisture content in soil
5. Estimation of soil organic carbon using Walkley Black method
6. Determination of titratable acidity of an acidic soil by BaCl₂-TEA method
7. Determination of soil enzymes (Cellulase, Protease and dehydrogenase)
8. Determination of soil microbial population
9. Soil taxonomy in India

Text books:

- ✓ *Mirsal, I.A. 2008. Soil Pollution Origin, Monitoring & Remediation (2nd edition), Springer Berlin, Heidelberg*
- ✓ *Brady, N.C. & Well, R.R. 2007. The Nature and Properties of Soils (13th edition), Pearson Education Inc*
- ✓ *Saha, J.K; Seladurai, R; Coumar, M.V; Kundu, S. & Patra, A.K. 2017. Soil Pollution - An Emerging Threat to Agriculture. Springer; 1st ed.*

Core XIX

Computational Methods in Environmental Science

Course Outcomes:

- Enhancement of computational skill to analyze the environmental data with hands-on experience with statistical/data tools/techniques involving computer applications.
- Enabling students to become familiar with different data sources relating to various aspects of the environmental issues.

Unit 1:

What are Computers? Input and output devices, Central Processing Unit, Software and hardware. Printer types and principles, IP address, Programming languages for scientific/environmental application, type of operating systems, basic tools for analysing environmental data

Unit 2:

Introduction to MS Excel: Spreadsheet basics and inputting of data, storing data, manipulating data, formatting of data, data error check, to prepare Line Graph, Column Chart, Histogram, Pie Chart and Scatter Plot.

Unit 3:

Measures of Central Tendency - Mean, Median and Mode; Arithmetic Mean, Geometric Mean and Harmonic Mean; Measures of Dispersion – Standard Deviation and Variance; Skewness; Kurtosis. Focus should be on mathematical/statistical/financial functions in MS Excel, and interpretation of numbers & Data Analysis.

Unit 4:

Geographical Information System (GIS), Spatial attribute Data collection and input to GIS software for analysis and hand on practice. Concept, definition & components. Spatial data and its analysis, Map type, Map Scale, Map Projection, Geo-referencing, Digitization, Ground Control Point (GCP), vector and raster data, Basic analysis using GIS tools, Spatial analysis, application of GIS in environmental analysis and management.

Practicals/Assignment/Project: Based on the theory

Text Books:

- ✓ *A Textbook on Fundamentals of Calculus: By Kumar Chaitanya, Bhavneet Kaur, and Harinderjit Kaur Chawla*
- ✓ *Computer Fundamentals and Programming in C: By Ikvinderpal Singh*
- ✓ *Let us C, Let us C++: By Yashwant Kanetkar*

Core XX

Semester VIII

Research Methodology & Ethics

Course Outcomes

- Identification, selection and formulation of research objectives
- Components, types and importance of research design
- Quoting, paraphrasing and avoiding plagiarism
- Literature search technique using SCOPUS and Google Scholar
- Citing and referencing methods and tools
- Presentation of research findings: Tables, Figures and pictures using Excel and other software

Unit I: Introduction to Research Methodology

Meaning of Research, Objectives of Research, Types of Research (qualitative, quantitative, cross sectional, longitudinal, pure, applied, evaluation, historical, survey, exploratory and case study), Significance of Research, Criteria of Good Research.

Unit II: Methods of research

Qualitative and Quantitative. Systematic review of literature, Features of good research study. Research ethics (Issues relating to referencing and documentation, copyrights, plagiarism, royalty, Intellectual property rights and patent law, Trade Related aspects of Intellectual Property Rights), Reproducibility and accountability.

Unit III: Research Techniques

Computer based techniques: Computer applications in biology. Spreadsheet tools: Introduction to spreadsheet applications, features, using formulas and functions, data storing, features for statistical data analysis, generating charts / graph and other features, presentation of power point presentation, customizing presentation, use of computers in quantitative analysis. Tools for digital image processing.

Unit IV: Scientific conduct & Publication Ethics

Ethics with respect to Science and Research, intellectual honesty and research integrity, scientific misconducts, misrepresentation of data, publication ethics and conflicts of interest.

Suggested Readings

- ✓ Allison, B. *The Students' Guide to Preparing Dissertations and Theses*. London: Kogan Page, 1997. Print.
- ✓ Altick, Richard D. and John J. Fenstermaker. *The Art of Literary Research*. 4th ed. New York: Norton, 1993. Print.
- ✓ Gibaldi, Joseph. *MLA Handbook for Writers of Research Papers*. 7th ed. New Delhi: East-West Press, 2009
- ✓ Kothari, C.R. *Research Methodology: Methods and Techniques*. New Delhi: New Age International Ltd, 1985.
- ✓ Rahim, F. Abdul. *Thesis Writing: A Manual for Researchers*. New Delhi: New Age International Pvt Ltd, 1996.
- ✓ Turabian, Kate l. *A Manual for Writers of Term Papers, Theses and Dissertations*. 6th ed. Chicago: Chicago UP, 1996.
- ✓ Wayne C. Booth, Gregory G. Colombo, Joseph M. Williams and William C. Booth. *The Craft of Research: From Planning to Reporting*. Chicago: Chicago UP, 2008.

Core XXI

Industrial Pollution Control and Management

Course Outcomes

- Understanding on the key terminologies related to industrial pollution and pollutants.
- Understanding about industrial pollutants, their permissible limits.
- Identification and analysis of industrial pollutants.
- Implementation of pollution prevention strategies.
- Assess the ecological and human health impacts of specific pollutants, considering short-term and long-term consequences due to industrial pollution

Unit 1

Type of polluting industries, Industrial air pollution control devices used, Discuss the operations of gravity settling chamber, cyclones, scrubbers, filters, ESP; Control of motor

vehicle emissions & various norms used in transport sector, Stack monitoring for Thermal power plant, Steel plants, Textile and Generator; Air Pollution (Prevention and Control) Act-1981.

Unit 2

Industrial water pollution control and management: Sources and characteristics of industrial wastewater, Standards related to industrial wastewater, Primary, Secondary and Tertiary treatment of industrial wastewater. Advanced technology for removal of toxic ions from industrial effluents such as Ion exchange, Electro dialysis, Reverse osmosis, Membrane technology, Ozonation, Wet air oxidation used in Textiles, Tanneries, Pulp and paper, Sugar & Distilleries, and fertilizers; Water Pollution (Prevention and Control) Act-1974.

Unit 3

Industrial solid wastes pollution control and management, Characteristics of solid wastes from food; fish processing unit; sugar industry; pulp and paper industries; coal based Thermal power plants; bio-medical waste and Municipal solid waste; Types and source of Waste and its composition, Bio-medical waste, E-Waste, Concept of 3R's- Recycle, Reuse, Reduce Hazardous Waste Management & Handling rules-1989.

Unit 4

Industries setting and Guideline for Environmental clearance Industrial scenario, Categories of industries that require environmental clearance as per impact assessment notification 1994, Public hearing preparation of EIA and EMP, Environmental protection Act 1986, EIA Notification 1989 (amended 1994), Notification 1997; National Environmental Policy -2006.

Practical (Any Six)

Collection of industrial wastewater and analysis of:

1. pH
2. Electrical Conductivity
3. TDS
4. TSS
5. DO
6. BOD
7. COD

Collection of soil from industrial area and analysis of

1. pH
2. Electrical Conductivity
3. Soil organic carbon content
4. Heavy metals content

Suggested Readings

- ✓ Rao. C.S., “*Environmental Pollution and Control Engineering*”, 2nd Edition, Revised, New Age International, 2007
- ✓ Mahajan. S.P., “*Pollution Control in Process Industries*”, Tata-McGraw Hill, New Delhi, 1985. Ref.
- ✓ Narayana Rao, M. and Datta, A.K., “*Wastewater Treatment*”, 2nd Edition, Oxford and IBH Publications, New Delhi, 2005.
- ✓ Swamy, A.V.N., “*Industrial Pollution Control and Engineering*”, Galgotia Publications, Hyderabad, 2005.
- ✓ Narayanan, P. 2018. *Environmental Pollution*. CBS Publishers & Distributers. New Delhi.
- ✓ Purohit, S.S. 2011. *Environmental Pollution: Causes, Effects and Control*. Vatsal Enterprises, New Delhi.
- ✓ Santra, S.C. 2017. *Environmental Science*. New Central Book Agency (P) Ltd., Kolkata.
- ✓ Anjaneyulu and Narasimha, R. 2009. *Introduction to Environmental Science*. B.S. Publications, Hyderabad.
- ✓ Katyal, T. and Satake, M. 2005. *Environmental Pollution*. Anmol Publication, New Delhi.
- ✓ Kannan, K. 2006. *Fundamentals of Environmental Pollution*. S. Chand and Company, New Delhi.

Core XXII

Environmental Toxicology

Course outcomes:

- Understanding on the sources, origins and effects of various toxicants that adversely impact environmental health.
- Developing perspective on the movement of toxicants in different components of environment, in different levels of biological organization and in trophic transfer across the food chain.
- Understanding on the relationship between types of contaminants and impact on human health. Trains on the methods used to assess the ecotoxicological impact and human health issues due to increase in the levels of contaminants in environment.

Unit I: Basic concepts of Eco-toxicology

Introduction to ecotoxicology: Principles of toxicology, scope of toxicology. Types of toxic substances - degradable and non-degradable. Factors influencing toxicity, distribution & fate of toxicants in the environment and organisms.

Unit II: Toxicants in the Environment

Toxic substances in the environment, their sources and entry routes. Transport of toxicants by air and water: Transport through food chain - bioaccumulation and biomagnification of toxic materials in food chain. Toxicology of major pesticides- biotransformation, biomonitoring, Concept of bioindicator and examples.

Unit III: Evaluation of toxicity

Methods used to assess toxicity classification of toxic materials. Concepts of Bioassay-types, characteristics. Importance and significance of bioassay, Threshold limit value, LC50, LD50. Concept of Dosimetry: lethal, sub-lethal & chronic tests. Interaction of toxicants: synergism, antagonism, additive effect, Dose response curves.

Unit IV: Organ toxicity and applied toxicology:

Hepatotoxicity: Common examples of hepatotoxicants, injuries caused to liver, Nephrotoxicity: Common examples of nephrotoxins, injuries caused to kidney, Pulmonary toxicity: Common examples of pulmonary toxicants, injuries caused to lungs. Neurotoxicity: Common examples of neuro toxicants, injuries caused to nervous tissues.

Practical

1. Ecotoxicology – based on the syllabus and contemporary research, such as Estimation of heavy metals.
2. Analyses of responses in living organisms to contaminants
3. Determination of fate of toxicants in living organisms or environment

Text Books:

- ✓ *Zakrzewski S, Environmental Toxicology, 3rd, Ed., Oxford Univ. Press*
- ✓ *Wright D.A. & Welbourn, P., Environmental Toxicology, Cambridge Univ. Press*

- ✓ *Loomis & Hays, Loomis's Essentials of Toxicology, 4th Ed., Academic Press*
- ✓ *Klaassen, CD., Amdur, M.D., Doull, J. (ed.), Toxicology, Mac Millan Pub. Company.*
- ✓ *Environmental biology and Toxicology, by Sharma P.D. Rastogi and Lamporary., 1994.*

Core XXIII

Environmental Geosciences and Mining

Course Outcomes:

- Understanding of physical process of earth and formation of minerals and rock.
- Overview on the mining areas across the country as resources and its usage.
- Overall understanding on environmental impacts of mining.

Unit 1: Earth Processes & Minerals:

Origin of earth. Primary geochemical differentiation and formation of core, mantle, crust, atmosphere and hydrosphere, Plate tectonic, continental drift, Earthquake and seismic waves,

Physical and optical properties of rock forming minerals and ore minerals. Chemical composition and origin of important rock forming minerals groups.

Unit 2: Igneous & Sedimentary Rocks:

Introduction to Magma and lava, Forms and structures of intrusive and extrusive rocks. Sedimentary processes and environments, Sedimentary rocks – texture and structure; sedimentary rock types, Metamorphic rock: Physico-chemical conditions, types of metamorphism, grade, metamorphic rock types.

Unit 3: Economic Mineral deposits

Economic mineral deposits: metal and non-metal deposit, extraction of metals. Uses of common metal and their recycling, radioactive minerals. important deposit of economic mineral in India.

Unit 4: Mining Geology

Environmental impact of mining and processing of minerals, mining dump and byproducts, conservation of mineral resources, Environmental impacts of uses of fossil fuels, Case studies on mining operations and environmental impacts.

Practical:

1. Megascopic identification of Rock forming minerals and rocks
2. Microscopic identification of Rock forming Minerals and Rocks
3. Field visit to well-exposed area for study.

Text Book

- ✓ *Mahapatra G.B. A text book of Physical Geology*
- ✓ *Bangar K.M. Principals of Engineering Geology*
- ✓ *Dexter Perkins (2015). Mineralogy 3rd edition, Pearson*
- ✓ *Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall.*
- ✓ *Pettijohn, F.J. (1975). Sedimentary Rocks. 3rdEdn. Harper and Row Publ., New Delhi.*
- ✓ *Philpotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall.*
- ✓ *Tucker, M.E. (1981). Sedimentary Petrology: An Introduction, Wiley & Sons, New York.*
- ✓ *Tiwari SK (2021). Mining and Environmental Science. Atlantic Publishers, New Delhi. 376 pp.*

- ✓ *Dhar BB and Thakur DN (1996). Mining Environment. 1st Edition. CRC Press. 416 PP.*
- ✓ *Spitz K and Trudinger J (2019). Mining and the Environment: From Ore to Metal. CRC Press. 812 PP.*