

Department of Environmental Studies
North-Eastern Hill University

M.Sc. (Environmental Science) Syllabus

Under Choice Based Credit System (as per NEP 2020)

The objective of the programme is to expose students to the wide knowledge base of the environment, its components and the principles operating therein. The students will also gain specialized knowledge on contemporary environmental issues and problems so as to attempt in solving them, and also will disseminate the same to the society. The programme will enable the students to develop analytical skills, investigation capabilities and hone their decision-making skills in the areas of environmental Science.

Students will also take part in practical sessions which are focussed on laboratory techniques that allow them to acquire lab skills. The practical skills are critical and indispensable to effective holistic learning and will enable them to engage effectively with advanced laboratory modules and prepare them for future employment.

The salient features of the revised syllabus are as follows:

1. The Master degree program in Environmental Science shall have a total of 88 credits and 1 credit is equivalent to 25 marks.
2. Every paper will have 25% credit as Internal Assessment and 75% credit as End semester examination.
3. The entire credits to be earned have been spread over four semesters.
4. Course No. ENV-GEC 504 in the first semester is multidisciplinary (GEC) course and students from other departments may opt this course.
5. Students may earn up to 40% of credits from MOOCS PG in lieu of DSEC and GEC.

M. Sc. Syllabus

FIRST SEMESTER		
Paper Code	Paper Name	Credit
ENV-CC: 500	Environment, Ecology and Ecosystem Dynamics	4
ENV-CC: 501	Environmental Pollution	4
ENV-DSEC: 502	Forest Management	4
ENV-DSEC: 503	Remote Sensing and Geographical Information System	4
ENV-GEC: 504	Contemporary Environmental Issues and Problems of India	4
	First Semester Total Credits	20
SECOND SEMESTER		
ENV-CC: 505	Environmental Microbiology, Biotechnology and Toxicology	4
ENV-CC: 506	Environmental Impact and Risk Assessment	4

ENV-DSEC: 507	Natural Resource Management	4
ENV-DSEC: 508	Radiation Biology	4
ENV-RM: 509	Research Methods, Techniques and Statistical Analysis	4
ENV-SEC: 510	Analytical Methods in Environmental Sciences	4
	Second Semester Total Credits	24
THIRD SEMESTER		
ENV-CC: 600	Energy and Environment	4
ENV-CC: 601	Environmental Economics and Sociology	4
ENV-CC: 602	Biodiversity Conservation and Ecosystem Services	4
ENV-DSEC: 603	Environmental Disasters: Mitigation and Management	4
ENV-DSEC: 604	Behavioural and Wildlife Ecology	4
ENV-DSEC: 605	Instrumentation Techniques: Principles and Applications	4
	Third Semester Total Credits	24
FOURTH SEMESTER		
ENV-DSEC: 606	Study Tour (visit to sites of environmental significance) and Dissertation (DSEC)	20
	Study Tour (visit to sites of environmental significance)	1
	Dissertation	15
	Presentation and Viva-Voce	4
	Fourth Semester Total Credits	20
	Total Course Credits	88

CC: Core Course; DSEC: Discipline Specific Elective Course; GEC: General Elective Course (Multidisciplinary), RM: Research Methodology and SEC: Skill Enhancement Course

FIRST SEMESTER

ENV-CC: 500 Environment, Ecology and Ecosystem Dynamics

Credit-4

Objective: To introduce the basic concepts of environment, basic structure and functions of population, community and ecosystem, understanding of distribution and cycling of energy and matter in ecosystem.

Unit I: Concept of environment: Scope of Environmental Science, environmental components, scope and subdivisions of ecology, ecological principles pertaining to population, community, ecosystem and biome. Energy in ecosystem: Primary and secondary production, Biomass, Methods of measuring productivity, Pattern of primary production in the major ecosystems of the world, Energy flow in ecosystems, Feedback and control mechanism, Pathways of energy transfer, grazing and detritus food chain, Ecological efficiency and ecological pyramids.

Unit II: Population and Community dynamics: Population dynamics and population regulations, concept of carrying capacity, population fluctuations, population dispersion, r and k selection, ecotypes and ecophene, keystone species, habitats and niches. Community concept: Definition, types and interaction - predation, herbivory, parasitism and allelopathy, biological invasions; Qualitative and quantitative characters of community: Ecological niche, Methods of studying vegetation, Species diversity and its measurement.

Unit III: Biogeochemical cycles: nutrient cycling in the ecosystems, Gaseous cycles (Carbon and Nitrogen) and sedimentary cycles (Phosphorus and Sulphur): Impact of man on nutrient cycles: Major ecosystems of the world: A general idea of forest, grassland, desert, wetland, freshwater and marine ecosystems.

Unit IV: Study of community structure in terrestrial ecosystem by frequency, density, abundance and Importance Value Index; Estimation of species composition in terrestrial and aquatic ecosystems; Measurement of primary productivity of a grassland and pond ecosystems; Estimation of moisture, pH and conductivity of soils under different land uses.

Learning Outcome: Student should be able to gain the knowledge about the environment and its components and functions.

Suggested Reading:

1. Botkin, Daniel B. (2011) *Environmental Science: Earth as a Living Planet*, John Wiley and Sons, New Delhi.
2. Miller, G. Tyler and Scott Spoolman (2011) *Essentials of Ecology*, Brooks/Cole Learning, USA.
3. Edward J Kormondy (2017) *Concepts of Ecology* (4th edition), Pearson India
4. Michael Begon Robert W. Howarth (2018) *Essentials of Ecology*, Wiley India.
5. Odum, E. P. (1996) *Fundamentals of Ecology*, Nataraj Publisher, Dehra Dun.
6. Molles Jr, M. C. (1999) *Ecology-Concepts and Application*, Mc Graw Hill, New Delhi.
7. Ingegnoli, V. (2002) *Landscape Ecology: a widening foundation*, Springer, Bonn.
8. Chapman, J. L. and Reiss M. J. (2005) *Ecology: Principles and Applications*, Cambridge University Press, London.
9. Odum, E. P. and G. W. Barrett (2005) *Fundamentals of Ecology*, Thomson Asia Pvt. Ltd., Singapore.

10. Rana, S.V.S. (2013) *Essentials of Ecology and Environmental Science*, Prentice Hall of India, New Delhi.
11. Reddy, Anji, M. (2005) *Textbook of Environmental Science and Technology*, BSP Books Pvt. Ltd., Hyderabad.
12. Anjaneyulu, Y. (2009) *Introduction to Environmental Science*, B S P Books Pvt. Ltd., Hyderabad.
13. Misra, R. (1968) *Ecology Workbook*, Oxford & IBH Publications Co., New Delhi. Michael, P. (1984) *Ecological Methods for Field and Laboratory Investigation*. Tata McGraw-Hill, New Delhi
14. Mueller-Dombois, D. and Ellenberg, H. (1974) *Aims and Methods of Vegetation Ecology*, John Wiley and Sons, New York.
15. Dash, M. C. and Dash, S. P. (2009) *Fundamentals of Ecology (3rd edn.)*. Tata McGraw-Hill Publishing Co., New Delhi.

ENV-CC: 501 Environmental Pollution

Credit-4

Objective: To give students an understanding regarding the various pollution sources in environment and their effect on environment and life.

Unit I: Types and sources of air, water and oil pollution, monitoring of air and water pollution, noise pollution, impact of pollution on human health, environment and assets; Water Pollution control technologies: Waste water treatment, primary treatment, secondary treatment and Advance treatment. Air pollution control technologies and devices: Limestone injection and fluidized bed combustion, Desulfurization; Catalytic converter and control of vehicular emission, Gravity settling chamber, Centrifugal collectors- cyclone collector and dynamic precipitators; Electrostatic precipitators; Fabric filters.

Unit II: Solid, Toxic and Hazardous waste management: solid waste disposal methods—open dumps, ocean dumping, landfills, incineration; Recycling and reuse: Organic pollutants; pesticides - organochlorine insecticides, organophosphates and carbamates; Fertilizers, Hazardous waste disposal and management corporate social responsibility.

Unit III: Electronic waste (E-waste): Sources and types, constituents of e-wastes, recycling of e-waste and its environmental consequences, Trans-boundary movement and management of e-wastes, Basel convention, Radioactive wastes: Types, hazards, storage and management.

Unit IV: Estimation of temperature, pH, conductivity and turbidity of water samples; Determination of SPM in ambient air by Respirable dust sampler, Estimation of dissolved oxygen (DO) and biochemical oxygen demand (BOD) of water samples chloride, nitrate, sulphate and phosphate in water samples, composition of municipal solid wastes

Learning Outcome: Students should get a clear idea regarding pollution, pollutants and their various effects on humans as well as ecosystem which will make them careful in future.

Suggested Reading:

1. Santra, S. C. (2015) *Environmental Science*, New Central Book Agencies, Pvt., Ltd. Kolkata
2. Botkin, Daniel B. (2011) *Environmental Science: Earth as a Living Planet*, John Wiley and Sons, New Delhi.
3. Cunningham, W. P. and W. B. Saigo (2005) *Environmental Science*, Mc Graw Hill, New York.
4. Bell, J. N. B. (2002) *Air Pollution and Plant Life*, (IEd.), John Wiley and Sons, New Delhi.
5. Cheremisinoff, N. P (1996) *Biotechnology for Waste and Waste water Treatment*, William Andrew Publishing, New York.
6. Fellenberg, G. (1999) *Chemistry of Pollution*, John Wiley and Sons, New Delhi.
7. Tirvedi, R. K. and Geol, P. K. (2010) *An Introduction to Air Pollution*, (IEd), DVS Publication, New Delhi.
8. Fin layson-Pitts, (1986) *Atmospheric Chemistry: Fundamentals and Experimental Techniques*, John Wiley and Sons, New Delhi.
9. Arya, S. P. (1999) *Air Pollution: Meteorology and Dispersion*, Oxford University Press, London.

10. Reddy, P. Jayarama (2011) *Pollution and Global Warming*, B S P Books Pvt. Ltd, Hyderabad.
11. De, A. K. (2000) *Environmental Chemistry*, New Age International Pvt., Ltd., New Delhi.
12. Rao, M. N. and Sultana, R. (2011) *Solid and Hazardous Waste Management*, B P S Books Pvt. Ltd, Hyderabad
13. Abbasi, S. A. and E., Ramasami (1999) *Biotechnological Methods of Pollution Control*, University Press, Hyderabad.
14. Reddy, Jayarama P. (2011) *Municipal Solid Waste management: Processing, Energy Recovery Global Examples*, BSP Books Pvt. Ltd, Hyderabad.
15. American Public Health Association (2012) *Standard Methods for Examination of Water and Wastewater*, (22nded.), American Public Health Association Inc., Springfield, New York.

Objective: To give students an understanding about the various forest management practices and their suitability in forest management.

Unit I: Forest: definition, growth stages, crown differentiation, classification of forest, forest types of India, measurement of height and girth of trees, form factor, estimation of volume of logs, role of forestry in environmental conservation Management: definition, principles of forest management, objectives of forest management, Rotation and kinds of rotation, Land expectation value. Forest regeneration, Periodic blocks, Normal forest, Estimation of normal growing stock. Silviculture systems: definition, characteristics, scope and classification; Clear felling systems; Uniform system, Indian Irregular Shelter wood system, Selection system, Coppice system, Management of Bamboo, traditional forest management systems in northeast India.

Unit II: Social Forestry: Origin, definitions, objectives, scope, place of social forestry in National Forest Policies., Multi purpose tree species (MPTs), Nitrogen fixing tree species (NFTs), characteristics of MPTs, NFTs. Community participation in social forestry programme, Pattern of planting, calculation of number of plants (line, square, triangular and quincunx), Eco-restoration of eroded hill slopes and degraded Jhumland, Tree species suitable for different edaphic conditions.

Unit III: Agroforestry: Origin and definition, type, gains of agro forestry system, Tree and crop management, Production potential of alley cropping, Agroforestry models developed for hill farming system- Three tier system, Tree-green hedge-crop Farming system and Contour- Tree-Green hedge- Crop Farming system, Acidic, Saline and alkaline soils and their reclamation techniques.

Unit IV: Inventorization of multipurpose trees (MPTs) and Nitrogen fixing trees (NFTs), measurement of height and girth of trees, estimation of volume of logs, Seed viability and Germination Tests,

Learning outcome: Student should be able to gain the knowledge about various forest management practices with reference to forest management in India.

Suggested Reading:

1. Agrawal, P. (2008) *Forest Mensuration*, Bishen Singh Mahendrapal Singh, Dehradun
2. Ghosh, S. K. and Singh, R. (2003) *Social Forestry and Forest Management*, Global vision publication, Delhi.
3. Dwivedi, A. P. (2003) *A Text Book of Silviculture*, Intl. Book Distributors, Dehradun.
4. Jha, L. K. and Sen Sarma, P.K. (2008) *Forestry for the people*, APH publishing corporation, New Delhi
5. Jha, L. K. and Sen Sarma, P. K. (2008) *Agroforestry: Indian Perspectives*, APH Publishing Corporation, New Delhi.
6. Jha, L. K. (2009) *Advances in Agroforestry*, A P H Publication Corporation, New Delhi
7. Jha, L. K. (1995) *Shifting Cultivation*, A P H Publishing Corporation, New Delhi.
8. Singh, G., Arora, Y. K. Narain, P. and Grewal, S.S.(1990) *Agroforestry Research in India and Other Countries*, Surya Publication, Dehra Dun.
9. Biswas, A. K. (2007) *Water resources: Environmental Planning, Management, and Development*, McGraw-Hill, New Delhi.

10. Khanna, L. S. (2004) *Theory and Practice of Indian Silviculture*, Khanna Bandhu, Dehradun
11. Ghosh, S. K . and Singh, R. (2003) *Social Forestry and Forest Management*, Global Vision publication, Delhi.

ENV-DSEC: 503 Remote Sensing and Geographical Information System Credits-4

Objective: To provide an understanding regarding remote sensing, its principles and characteristics, different platforms, an introduction to the major remote sensing systems, its potential applications to environmental monitoring and natural resources conservation.

Unit I: Remote sensing: definition and scope; Electro-magnetic radiation: characteristics, interaction with matter and spectral regions. Aerial photos: Types, Scale, Resolution; Stereoscopy; Geometric properties of aerial photos; Stereoscopic parallax; Relief displacement.

Unit II: Types of remote sensing; Remote sensing regions and bands. Indian and foreign Remote Sensing Satellites- LANDSAT, IRS, IKONOS, QUICK BIRD, CARTOSAT. Platforms and sensors- principles and geometry.

Unit III: Image classification procedures; supervised and unsupervised classifications. Elements of aerial photo-interpretation, Elements of Visual Interpretation, Satellite Imageries and its application in Environmental Monitoring, Land use Mapping, Habitat Analysis, Drought Monitoring and Flood Studies, Soil Conservation and Watershed Management, Urban sprawl, Landslide hazard zonation and geosciences.

Unit IV: GIS: Introduction, components and software modules. Geographic data: spatial and non- spatial. Data-structure. Application of GIS in Land use Mapping, Habitat Analysis, Urban sprawl and Landslide hazard zonation. GIS as a decision support system; Global positioning system: Basic principles, instruments, components and applications of GPS.

Learning outcome: Students should be able to understand and use the application of remote sensing and GIS in Environmental Science.

Suggested Reading:

1. Lillesand, T.M. and Kiefer, R. W. (1987) *Remote Sensing and image interpretation*, John Wiley, Cambridge.
2. Chang, Kang-tsung (2000) *Introduction to GIS*, Tata McGraw Hill, New Delhi.
3. B. Bhatta (2011) *Remote Sensing and GIS*, Oxford University Press, New York.
4. Susan L. Ustin (2004) *Remote Sensing for Natural Resource Management and Environmental Monitoring*, John Wiley & Sons,
5. Eric Charles Barrett and Leonard Frank Curtis (1992) *Introduction to Environmental Remote Sensing*, Routledge, Taylor and Francis, New York.
6. Wing, Michael G., Pete Bettinger (2008) *Geographic Information Systems: Applications in Natural Resource Management*, Oxford University Press, New York.
7. Johnson, Arnold Ivan, C. Bernt Petterson (2008) *Geographic Information Systems (GIS) and Mapping: Practices and standards*, ASTM International.
8. Ahmed El- Rabbany (2002) *Introduction to GPS: The Global Positioning System*, Artech House
9. Remote, John R Jensen (2000) *Sensing of the Environment*, Prentice Hall
10. Reddy, Manji (2008) *Text book of Remote Sensing and Geographical Information Systems (2nd edition)*, Book Syndicate

ENV-DSEC: 504 Contemporary Environmental Issue and Problems of India

Credit-4

Objective: To develop perspective on important environmental issues that have become a matter of national policy making

Unit I: Population growth, urbanization, decrease in rural population, Human development Index in India, Human Happiness Index in India, smart cities and other environment friendly human settlements, urban and rural settlements in the past of India with respect to health and environment.

Unit II: Forest area, cover, composition; biodiversity, biodiversity conservation and protection, protected areas, sacred forests and groves; agriculture systems, shifting, mechanised, organic and natural, green revolution, traditional food crops, high yielding varieties, use of fertilizers, pesticides and chemicals; rivers and other water resources; coal and mineral resources, Forest Acts of India.

Unit III: Impacts of colliery, quarrying and mining, oil refineries, cement plants, paper mills, wood-based industries. Impact of tourism, vehicle growth, roads, other modes of transportation. Impact of solid waste, electronic waste, plastic and other wastes on air, water and soil. contamination: Impact of deforestation and agriculture on desertification.

Unit IV: Constitution of India on environment, Articles 48 A, Article 21, Article 253, Article 51, 51 (A), Article 14, Article 19 (1) (g); Pollution Control Boards (Central and State), National Green Tribunal Act 2010, Air (Prevention and Control of Pollution) Act 1981, Water (Prevention and Control of Pollution) Act 1974, Environment Protection Act 1986, Municipal Solid Waste Management and Handling Rules 2016.

Learning Outcome: Students will understand the environment of India, sustainable use of renewable and non-renewable resources, problems and issues, and their solutions.

Suggested Reading:

1. Das, A. (2014). *Environment, Natural Resource and Economy*, New Century Publications.
2. Narindar, J. K. (2010). *Human and Natural Resources of India*, New Century Publications.
3. Rath, P. (2018). *Demographic Profile of India*, Blue Rose Publishers.
4. Majumdar, P. K. (2013). *India's Demography: Changing Demographic Scenario in India*, Rawat Publications.
5. Sengupta, M. (2021) *Environmental Impacts of Mining: Monitoring, Restoration and Control*, Second Edition. CRC Press.

SECOND SEMESTER

ENV-CC: 505 Environmental Microbiology, Biotechnology and Toxicology Credit-4

Objective: To make students aware of the role of microbiology, biotechnology and toxicology in the sustenance of environment and application of concepts of microbiology and biotechnology in Environmental Sciences.

Unit I: Scope and importance of microorganisms; Microorganism in different environments - soil, water, air and extreme environments, Reproduction and growth, methods for determining bacterial numbers, Role of microorganisms in waste treatment, Anaerobic (methano genesis) and aerobic (trickling filter, activated sludge, oxidation pond) treatment of wastewater, production of enzymes and alcohol.

Unit II: Biotechnology in environment protection: Role, current status; Biotechnology derived tools and processes; Industrial ecology and biotechnology; Bioplastics and biosensors for environmental monitoring; Green chemistry and its applications, Genetically Modified Organisms (GMOs) and their possible environmental implications.

Unit III: Principles in toxicology; Toxicants and toxicity, Factors affecting concentration of toxicants in environment, Toxicity tests and concepts of LD₅₀ and LC₅₀, Sources and types of toxicants and their health hazards, Dose-effect and Dose response relationship, Absorption, translocation and excretion of toxicants. Global dispersion of toxic substance, Dispersion and circulating mechanisms of pollutant, degradable and non-degradable toxic substances in food chain, Ecosystem influence on fate and transport of toxicants, Bio-absorption of heavy metals and Bio-accumulation, Biomagnification.

Unit IV: Estimation of microflora in forest and contaminated soil, potable, pond and waste water through dilution plate method,: Determination of heavy metal toxicity by germination and seedling growth tests: Analysis of toxic effect of pesticides on soil organisms, determination of LC₅₀/LD₅₀value of a toxicant, Estimation of microflora in forest and contaminated soil, potable, pond and drinking water.

Learning outcome: Student should be able to comprehend the activities and roles of microbes in the environment and acquaint themselves with their applications.

Suggested Reading:

1. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2002) *Molecular Biology of the Cell* (IV ed.), Garland Science, New York.
2. Abbasi, S. A. and E. Ramasami (1999) *Biotechnological methods of Pollution control* University Press, Hyderabad.
3. Jemba, P. K. (2004) *Environmental Microbiology*, Science Publishers, USA.
4. Srivastava, M. L. (2003) *Basic Environmental Microbiology*, Manohar Books, New Delhi.
5. Raina, M., I. Pepper and C. Gerba (2006) *Environmental Microbiology*, Academic Press, New York.
6. Murugesan, A. G. and Rajakumari. C. (2006) *Environmental Science and Biotechnology*, MJP Publishers, Chennai.
7. Hayes, W. A. (2001) *Principles and Methods of Toxicology*, CRC, USA.
8. Wright, D. A. and Welbourn, P. (2002) *Environmental Toxicology*. Cambridge University

- Press, London.
9. Klaassen, C. D and Watkins, J.B. (2003) *Essentials of Toxicology*, McGraw-Hill Professional, New Delhi.
 10. Jacobson-Kram, D. (2006) *Toxicological Testing Handbook: Principles, Applications and Data Interpretation*. Taylor & Francis, New York.
 11. Pelczar, Jr. M. J, Chan, E. C. S. and Krieg, N. R. (2009) *Microbiology, (eds.)*, Tata McGraw-Hill New Delhi.
 12. Walker, C. H., R. M. Sibly, S. P. Hopkin, and D. B. Peakall (2012) *Principles of Ecotoxicology*, (IV ed.), CRC Press, New York.
 13. Bommanna, G. Loganathan and Paul Kwan-Sing Lam (2011) *Global Contamination Trends of Persistent Organic Chemicals*, CRC Press, New York.

Objective: To make students understand how the impacts of a developmental activity can be assessed and adverse effects can be mitigated.

Unit I: Environmental impact assessment (EIA): definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA. Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental management system– principles, problems and strategies; environmental planning; environmental audit; introduction to ISO 14000; sustainable development goal.

Unit II: Role of project proponents, project developers and consultants; Terms of Reference; impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management systems (EMS).

Unit III: EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects, Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment. Risk assessment: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

Unit IV: Comparative study of soil biodiversity in polluted and unpolluted site: Study of an Environmental Impact Assessment report (case study): Visit to Industrial/Mining sites and preparation of report; Analysis of air, water and soil quality data of an Environmental Impact Assessment report (case study); Study of socio-economy of an area with the help of Census data; Rapid EIA of tourism

Learning outcome: It will enhance foundation on the concept and components of environmental impact assessment, develop the skill to write and design the draft of EIA report and risk assessment.

Suggested Reading:

1. Charles, H. Eccleston (2011) *Environmental Impact Assessment*, CRC Press, New York.
2. Anjaneyulu, Y. and Manickam, W. (2010) *Environmental Impact Assessment Methodologies*, BSP Books Pvt. Ltd., Hyderabad.
3. Lawrence, D. P. (2003) *Environmental Impact Assessment: Practical Solutions to Recurrent Problems*, John Wiley and Sons, New Delhi.
4. Glasson, Therivel and Chadwick (1999) *An Introduction to Environmental Impact Assessment*, UCLA, Los Angeles.
5. Morris, P. and R. Therivel (2001). *Methods of Environmental Impact Assessment*, Spoon Press.
6. Anjaneyulu, Y. (2002) *Environmental Impact Assessment Methodologies*, B.S. Publications, New Delhi.
7. Weston, J. (1997) *Planning and EIA in Practice*, Longman.
8. Jos Arts and Angus Morrison-Saunders (2004) *Assessing Impact - Handbook of EIA and SEA follow-up*, Earthscan, London.
9. Website of MoEFCC, GOI, New Delhi

Objectives: To make students appreciate the role of natural resources in the sustenance of life on earth and to explain and discuss the distribution of different natural resources and their sustainable management.

Unit I: Natural resources: Concept and major types of natural resources, Land Resources: Land use and land cover, land use change, drivers of land use change, impact of land use change on environment; Soil resource: soil types, profile and composition, degradation of land and soil; Mineral Resources: metal and non-metal minerals and their reserve and distribution, environmental effects of mineral exploitation.

Unit II: Energy and Mineral Resources: Definition of Energy; Sources of energy; Energy units; Energy Resources: Oil and natural gas, coal, solar and wind energy, biomass energy, geothermal energy, hydropower; Environmental implication of energy use; Mineral resources: types, distribution and reserves.

UNIT III: Water Resources: Introduction: distribution and supply: Global, national and regional; hydrological cycle, Water resource type: surface water, ground water; Causes of water resource depletion: Use and over use of water resources, Methods for managing water resources: Ground water recharging, rainwater harvesting; Watershed management: Concept and objectives, land use planning, flood control; Wetlands: definition, importance and classification.

Unit IV: Forest and Biodiversity: Forest as natural resource: importance, classification and extent of forests in India; deforestation and conservation strategies; Role of forests in carbon management; forest fragmentation, national forest policy; Biodiversity: introduction, levels, importance, threats to biodiversity, modern and traditional biodiversity conservation strategies, global biodiversity hotspots; threatened and endemic species.

Learning outcome: Helps to develop Skills in recognising and solving environmental and social impacts of resource depletion.

Suggested Reading:

1. Daniel D. Chiras and Reganold, John P. (2009) *Natural Resource Conservation: Management for a Sustainable Future* (X Ed.), Addison Wesley, Boston.
2. Biswas, A.K. (2007). *Water resources: Environmental Planning, Management and Development*, McGraw, Hill, New Delhi.
3. Flintan, F. and Tedla, S. (2010) *Natural Resource Management: The impact of gender and Social Issues*, IDRC, New Delhi.
1. Quentin Grafton, R. and Hussey, Karen (2011) *Water Resources Planning and Management*, Cambridge University Press, London.
2. Kesler, P. (2002) *Mineral resources: Economics and Environment*, CBS Publishers & Distributors, New Delhi.
3. Nakicenovic, N. (1998) *Global Energy Perspectives*, Cambridge University Press, London.
4. Ravindranath, N. H., Usha Rao, K., Natarajan, B. and Monga, P. (2002) *Renewable Energy and Environment - A Policy Analysis for India*, Tata-McGraw Hill, New Delhi
5. Kumar, Arun, Sati, J. P., Tak, P.C., and Alfred, J.R.B. (2005) *Handbook on Indian Wetlands and Their Conservation*, Zoological Survey of India, Kolkata.

6. Krishnamurthy, V. K. (2008) *Text Book of Biodiversity*, Science Publisher, Chennai.
7. Das, A.P. (2002) *Prospective of Plant Biodiversity*, Bishan Singh Mahendra Pal Singh, Dehradun.
8. Singh N. Irabanta (2008) *Endemic Bio-resources of India*, Bishan Singh Mahendra Pal Singh, Dehradun.

Objective: To know the relationship between matter, energy and release of energy (radiation) in the making and function of our environment and entire cosmos.

Unit I: Historical aspects: basics of radiation; types and source, natural and man-made; Radiation interaction with water, biological materials (nucleic acids, proteins, carbohydrates, lipids and membrane) and with other matters; units of radiation.

Unit II: Radiation and health effects; target theories, acute and delayed effects by radiation; radiation syndromes and cancer; mutagenic effect and chromosomal aberrations of radiation.

Unit III: Applied aspects of radiation in nature and environment: change in atomic numbers and weight in elements, source of energy in biological and non-biological world, carbon and other types of dating

Unit IV: Applications of radiation technology: radiation information technology; radiation in microscopy and mineralogy; radiation in scanning; radiation in food preservation; radiation as alternative source of energy.

Learning Outcome: Students will learn about role of basics of radiation, their health effects and applied aspects of radiation energy in the welfare of huma.

Suggested Reading:

1. Uma Devi P., Nagarathnam A. and Rao B. S. S. (2000). *Introduction to Radiation Biology*, B. I. Churchill Livinstone, New Delhi.
2. Valkovic V. (2000). *Radioactivity in the Environment*, Elsevier, Mumbai.
3. Chadwick (2019) *Understanding Radiation Biology*, CRC Press.
4. Gaetano L, Giovanni d'Amore and Magnoni, M. (2018). *Physical Agents in the Environment and Workplace: Noise, vibrations, electromagnetic fields and ionizing radiations*, Taylor & Francis, New Delhi.

ENV-DSEC: 509 Research Methods, Techniques and Statistical Analysis Credits-4

Objectives: To give students an understanding regarding environmental sampling, analysis and the various techniques associated.

Unit I: Definition of applied science and research, Classification of research. Critical appraisal of research studies, Planning research projects, Advance planning and its value, Methods of data collection and analysis, interpretation and presentation and report writing.

Unit II: Sampling techniques: Sampling of air, water and soil, sampling of plant and animal populations, concept of species area curve, concept of random and stratified sampling, Methods of Social Science research: PRA.

Unit III: Basic statistics: Population and sample, frequency table; measures of central tendency- mean, median, mode; measures of dispersion- standard deviation, variance; Correlation- Karl Pearsons co-efficient of correlation.

Unit IV: Tests of significance and experimental layout: Z test, Types of Z test (one sample and two sample), Standard error for Z test; Tests of significance for small samples: T-test (One sample, Two Sample: Independent and Dependent), F-test for comparison of variance; Goodness-of-fit test – Chi-Square test; Basic principles of field experimentation- randomization, replication and local control.

Learning Outcome: Students are expected to have a basic awareness on various separation techniques such as chromatography and analytical methods. Design scientific methods/experiments to study various ecological parameters and biodiversity in laboratory/field conditions.

Suggested Reading:

1. Chadda, A. (1989) *Agricultural Statistics in India*, Suman Book House, New Delhi.
2. Date, C. J. (1986). *An Introduction to data base system*, Addison Wesley, U. K.
3. Dear, K. J. B., Mead, R and Rilay, J. (1987) *Statistical Tools for Agroforestry Research*, ICRAF, Kenya.
4. Medhi, J. (1992) *Statistical Methods*. Wiley Eastern, New Delhi.
5. Gurumani, N. (2006) *Research Methodology for Biological Sciences*, M J P Publishers, Chennai.
6. Vic Barnett (2006) *Environmental Statistics: Methods and Applications*, John Wiley and Sons, New Delhi.

Objectives: To give students an understanding regarding separation techniques, analysis and the various associated techniques.

Unit I: Separation techniques: Adsorption, centrifugation, chromatography, crystallization, decantation, distillation, drying, electrophoresis, elutriation, evaporation, leaching, flotation, flocculation, filtration, reverse osmosis, dialysis (biochemistry), fractional distillation, fractional freezing, magnetic separation, precipitation, crystallization, sedimentation, sieving, stripping, sublimation, vapour-liquid separation, winnowing and zone refining.

Unit II: Sample Preparation and extraction: concept and importance, sample pre-treatment, preparation, post treatment techniques: pressurized liquid and subcritical hot-water extraction, microwave assisted extraction, solid phase extraction, QuEChERS approach of extraction, solid phase micro extraction, single drop micro extraction (SDME), membrane extraction, liquid-liquid extraction.

Unit III: Chromatography and Mass spectroscopy: Principle, instrumentation and application of gas, liquid, adsorption, paper, gel, size exclusion, HPLC, TLC, electrophoresis and ion exchange chromatography. Mass spectroscopy: Principle, instrumentation and application of mass spectroscopy, types of mass spectroscopy, fragmentation, ionization and characterization of organic and inorganic materials.

Unit IV: Miscellaneous methods Principle, instrumentation and application of classical analytical methods: gravimetric, volumetric and thermal methods); Automatic analytical methods and Hybrid analytical methods.

Learning Outcome: Students should be able to comprehend with various sampling technique and its applications.

Suggested Reading:

1. G. D. Christian (2007). *Analytical Chemistry*, 6th Ed, John Wiley & Sons.
2. H. A. Strobel and W. R. Heineman (1989). *Chemical instrumentation: a systematic approach*, Wiley,
3. H. H. Willard (1981). *Instrumental methods of analysis*, Van Nostrand.
4. Z. Marczenko and M. Balcerzak (2000). *Separation, preconcentration and spectrophotometry in Inorganic Analysis*, Elsevier.
5. E. Katz (2009). *Quantitative Analysis: Using Chromatographic Techniques*, John Wiley & Sons.
6. J. Rydberg, M. Cox and C. Musikas (2004). *Solvent extraction principles and practice*, CRC Press.
7. P. J. Haine (2002). *Principles of Thermal Analysis and Calorimetry*, Royal Society of Chemistry.
8. E. de Hoffmann and V. Stroobant (2007). *Mass Spectrometry: Principles and Applications*, John Wiley and Sons.