DEPARTMENT OF ENVIRONMENTAL STUDIES, NEHU, SHILLONG
FYUG SYLLABUS FOR B. SC. ENVIRONMENTAL SCIENCE
(Academic Council approval date: May 21, 2025)

Semester: 7				
Semester (Honours)	Course Code	**Course Title**	Paper	Credits
Honours	EVS-400	Research Methodology and Proposal Writing	1	4
Honours	EVS-401	Ecology and Environment Major Course	1	3+1=4
Honours	EVS-402	Waste and Pollution Management Major Course	1	3+1= 4
Honours	EVS-403	Remote Sensing and Geographical Information System Major Course	1	4
Honours	EVS-404	Environmental Issues and Problems of India Minor Course	1	4
Total Credits				**20**
Semester: 8				
Honours	EVS-450	Biotechnology, Microbial Technology and Toxicology Major Course *(For both Honours & Honours with Research)*	1	3+1=4
Honours	EVS-451	Environmental Impact and Risk Assessment Minor Course *(For both Honours & Honours with Research)*	1	3+1=4
Honours	EVS-452	Research Project/Dissertation *(For Honours with Research)*	1	12
Honours	EVS-453	Analytical Methods in Environmental Science Minor /Advance Course *(For both Honours only)*	1	4
Honours	EVS-454	Energy, Water and Forest Resources Minor /Advance Course *(For both Honours only)*	1	4
Honours	EVS-455	Radiation Biology Minor /Advance Course *(For both Honours only)*	1	4

SUB-405; 451 & 452: shall be a course for students choosing a 4 year UG Degree (Honours with Research)-20 credits

SUB-450; 454 & 455: shall be advance courses for students choosing a 4 years UG Degree (Honours)-20 credits

SEMESTER 7

EVS-400: RESEARCH METHODOLOGY AND PROPOSAL WRITING

Credits: 4 credits **Total Contact Hours: 60**

Learning Objective: To learn about research planning, methods of data collection, analysis, interpretation, presentation and report writing along with methods of environmental sampling, analysis and the various techniques associated.

Course Outcome: Students are expected to have a basic idea about research planning, data collection methods, interpretation of results and will also know various methods involved in environmental monitoring of air, water, soil and plant sampling. Students may also be able to design scientific methods/experiments to study various ecological parameters and biodiversity in laboratory/field conditions.

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.

Suggested Reading: (All latest editions)

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

EVS-401: ECOLOGY AND ENVIRONMENT

Credits: 4 credits **Total Contact Hours: 75 (45+30)**

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

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

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, community concept, 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, study 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.

Suggested Reading (All new editions):

Botkin, Daniel B. (2011) Environmental Science: Earth as a Living Planet, John Wiley and Sons, New Delhi.
Miller, G. Tyler and Scott Spoolman (2011) Essentials of Ecology, Brooks/ Cole Learning, USA.
Edward J Kormondy (2017) Concepts of Ecology (4th edition), Pearson India
Michael Begon Robert W. Howarth (2018) Essentials of Ecology, Wiley India.
Odum, E. P. (1996) Fundamentals of Ecology, Nataraj Publisher, Dehra Dun.
Chapman, J.L. and Reiss M.J. (2005) Ecology: Principles and Applications, Cambridge University Press, London.
Odum, E.P. and G.W. Barrett (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd., Singapore.

EVS-402: WASTE AND POLLUTION MANAGEMENT

Credits: 4 credits **Total Contact Hours: 60**

Learning Objective: To understand the sources and types of pollution in environment and their effect on environment and life.

Course Outcome: Students will get an idea about pollution, pollutants and their various effects on humans and surrounding.

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, study of composition of municipal solid waste.

Suggested Reading (all new editions):

Santra, S. C. (2015) Environmental Science, New Central Book Agencies, Pvt., Ltd. Kolkata
Botkin, Daniel B. (2011) Environmental Science: Earth as a Living Planet, John Wiley and Sons, New Delhi.
Cunningham, W.P. and W.B. Saigo (2005) Environmental Science, McGraw Hill, New York.
Bell, J.N.B. (2002) Air Pollution and Plant Life, (II ed.), John Wiley and Sons, New Delhi.
Cheremisinoff, N.P (1996) Biotechnology for Waste and Wastewater Treatment, William Andrew Publishing, New York.
Fellenberg, G. (1999) Chemistry of Pollution, John Wiley and Sons, New Delhi.
Tirvedi, R.K.and Geol, P. K. (2010) An Introduction to Air Pollution, (II Ed), DVS Publication, New Delhi.
Finlayson-Pitts, (1986) Atmospheric Chemistry: Fundamentals and Experimental Techniques, John Wiley and Sons, New Delhi.
Arya, S.P. (1999) Air Pollution: Meteorology and Dispersion, Oxford University Press, London.
Reddy, P. Jayarama (2011) Pollution and Global Warming, BSP Books Pvt. Ltd, Hyderabad.
De, A.K. (2000) Environmental Chemistry, New Age International Pvt., Ltd., New Delhi.
Rao, M.N. and Sultana, R. (2011) Solid and Hazardous Waste Management, BPS Books Pvt. Ltd, Hyderabad
Abbasi, S.A. and E., Ramasami (1999) Biotechnological Methods of Pollution Control, University Press, Hyderabad.
Reddy, Jayarama P. (2011) Municipal Solid Waste management: Processing, Energy Recovery Global Examples, BSP Books Pvt. Ltd, Hyderabad.

EVS-403: REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

Credits: 4 credits **Total Contact Hours: 60**

Learning Objective: To understand 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.

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

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, Landuse 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. 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.

Suggested Readings: (All latest editions)

Lillesand, T.M. and Kiefer, R. W. (1987) Remote Sensing and image interpretation, John Wiley, Cambridge.

Chang, Kang-tsung (2000) Introduction to GIS, Tata McGraw Hill, New Delhi.

Rao D. P. (ed.) (1998) Remote Sensing for Earth Resources, Association of Exploration Geophysicist, Hyderabad.

B. Bhatta (2011) Remote Sensing and GIS, Oxford University Press, New York.

Susan L. Ustin (2004) Remote Sensing for Natural Resource Management and Environmental Monitoring, John Wiley & Sons,

Eric Charles Barrett and Leonard Frank Curtis (1992) Introduction to Environmental Remote Sensing, Routledge, Taylor and Francis, New York.

Wing, Michael G., Pete Bettinger (2008) Geographic Information Systems: Applications in Natural Resource Management, Oxford University Press, New York.

Alberto Carrara, Fausto Guzzetti (1996) Geographical Information Systems in Assessing Natural Hazards, Kluwer Academic Publishers, Netherlands.

Conway, Eric D. (1997) An Introduction to Satellite Image Interpretation, Maryland Space Grant Consortium.

Johnson, Arnold Ivan, C. Bernt Petterson (2008) Geographic Information Systems (GIS) and Mapping: Practices and standards, ASTM International.

Ahmed El-Rabbany (2002) Introduction to GPS: The Global Positioning System, Artech House

Remote, John R Jensen (2000) Sensing of the Environment, Prentice Hall

Reddy, Manji (2008) Text book of Remote Sensing and Geographical Information Systems (2nd edition), Book Syndicate

EVS-404: ENVIRONMENTAL ISSUES AND PROBLEMS OF INDIA

Credits: 4 credits **Total Contact Hours: 60**

Learning Objective: To develop perspective on important environmental issues those have become a matter of national policy making and associated constitutional provisions.

Course Outcome: Students will get an idea about important environmental issues and will get sensitizing with the constitutional provisions pertaining to prevention of pollution.

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, mechanized, 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, pollutions (air and water); soil contamination and 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.

Suggested Readings: (All latest editions)

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

SEMESTER 8

EVS-450: BIOTECHNOLOGY, MICROBIAL TECHNOLOGY AND TOXCICOLOGY

Credits: 4 credits **Total Contact Hours: 75 (45+30)**

Learning Objective: To learn the role of microbiology, biotechnology and toxicology in the sustenance of environment and application of concepts of microbiology and biotechnology in Environmental Sciences.

Course Outcome: Student should be able to realize the activities and roles of microbes on earth and know how to use them in different applications for the betterment of life.

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 (methanogenesis) 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 LD_{50} and LC_{50}, 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 soil and 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 LC_{50}/LD_{50}value of a toxicant.

Suggested Reading: (All latest Editions)

Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2002) Molecular Biology of the Cell (IV ed.), Gasland Science, New York.
Abbasi, S. A. and E. Ramasami (1999) Biotechnological methods of Pollution control University Press, Hyderabad.
Jemba, P. K. (2004) Environmental Microbiology, Science Publishers, USA.
Srivastava, M. L. (2003) Basic Environmental Microbiology, Manohar Books, New Delhi.
Raina, M., I. Pepper and C. Gerba (2006) Environmental Microbiology, Academic Press, New York.
Murugesan, A.G. and Raja kumari. C. (2006) Environmental Science and Biotechnology, MJP Publishers, Chennai.
Hayes, W. A. (2001) Principles and Methods of Toxicology, CRC, USA.
Wright, D.A. and Welbourn, P. (2002) Environmental Toxicology. Cambridge University Press, London.
Klaassen, C. D and Watkins, J.B. (2003) Essentials of Toxicology, McGraw-Hill Professional, New Delhi.
Jacobson-Kram, D. (2006) Toxicological Testing Handbook: Principles, Applications and Data Interpretation. Taylor & Francis, New York.
Pelczar, Jr. M. J, Chan, E. C. S. and Krieg, N. R. (2009) Microbiology, (V ed.), Tata McGraw-Hill New Delhi.
Walker, C. H., R. M. Sibly, S. P. Hopkin, and D. B. Peakall (2012) Principles of Ecotoxicology, (IV ed.), CRC Press, New York.
Bommanna, G. Loganathan and Paul Kwan-Sing Lam (2011) Global Contamination Trends of Persistent Organic Chemicals, CRC Press, New York.

EVS-451: ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

Credits: 4 credits **Total Contact Hours: 75 (45+30)**

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

Course Outcome: It will lay 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.

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 (EIA) report, visit to Industrial/Mining sites and preparation of report. Analysis of air, water and soil quality data of an Environmental Impact Assessment (EIA) report, study of socio-economy of an area with the help of Census data.

Suggested Reading: (All latest editions)

Charles, H. Eccleston (2011) Environmental Impact Assessment, CRC Press, New York.
Anjaneyulu, Y. and Manickam, W. (2010) Environmental Impact Assessment Methodologies, BSP Books Pvt. Ltd., Hyderabad.
Lawrence, D. P. (2003) Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley and Sons, New Delhi.
Glasson, Therivel and Chadwick (1999) An Introduction to Environmental Impact Assessment, UCLA, Los Angeles.
Morris, P. and R. Therivel (2001). Methods of Environmental Impact Assessment, Spoon Press.
Anjanejuly, Y. (2002) Environmental Impact Assessment Methodologies, B.S. Publications, New Delhi.
Weston, J. (1997) Planning and EIA in Practice, Longman.
Jos Arts and Angus Morrison-Saunders (2004) Assessing Impact - Handbook of EIA and SEA follow-up, Earthscan, London.
Reddy, Anji, M. (2005) Textbook of Environmental Science and Technology, BSP Books Pvt. Ltd., Hyderabad.
Anjaneyulu, Y. (2009) Introduction to Environmental Science, BSP Books Pvt. Ltd., Hyderabad.
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
Mueller-Dombois, D. and Ellenberg, H. (1974) Aims and Methods of Vegetation Ecology, John Wiley and Sons, New York.

EVS-452: RESEARCH **PROJECT/ DISSERTATION**

Credits: 12 **Total Contact Hours: 180**

EVS-453: ANALYTICAL METHODS IN ENVIRONMENTAL SCIENCE
Credits: 4 credits **Total Contact Hours: 60**

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

Course Outcomes: Students should be able to comprehend with various sampling technique and its applications in the field of environmental science.

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.

Suggested Reading: (All latest editions)

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

EVS-454: ENERGY, WATER AND FOREST RESOURCES

Credits: 4 credits **Total Contact Hours: 60**

Learning Objective: To understand about energy resources, their environmental consequences and remedial measures.

Course Outcome: Student will be able to gain the knowledge about various energy resources, their importance and will helps to develop skills in recognizing and solving environmental and social impacts of energy resource depletion.

Unit I: Natural resources: Concept and major types of natural resources, Land Resources: Landuse and land cover, landuse-landcover change, drivers of landuse change, impact of landuse 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 off 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.

Suggested Reading: (All latest editions)

Daniel D. Chiras and Reganold, John P. (2009) Natural Resource Conservation: Management for a Sustainable Future (X Ed.), Addison Wesley, Boston.

Biswas, A. K. (2007). Water resources: Environmental Planning, Management and Development, McGraw, Hill, New Delhi.

Flintan, F. and Tedla, S. (2010) Natural Resource Management: The impact of gender and Social Issues, IDRC, New Delhi.

Quentin Grafton, R. and Hussey, Karen(2011) Water Resources Planning and Management, Cambridge University Press, London.

Kesler, P. (2002) Mineral resources: Economics and Environment, CBS Publishers& Distributors, New Delhi.

Nakicenovic, N. (1998) Global Energy Perspectives, Cambridge University Press, London.

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

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.

Krishnamurthy, V.K. (2008) Text Book of Biodiversity, Science Publisher, Chennai.

Das, A. P. (2002) Prospective of Plant Biodiversity, Bishan Singh Mahendra Pal Singh, Dehradun.

Singh N. Irabanta (2008) Endemic Bio-resources of India, Bishan Singh Mahendra Pal Singh, Dehradun.

EVS-455: RADIATION BIOLOGY

Credits: 4 credits **Total Contact Hours: 60**

Learning Objective: To get an understanding of historical aspects of radiation, its health effects and applied and commercial aspects of radiation.

Course Outcomes: Students should be able to understand the pros and cons of radiation and its applied and commercial application in welfare of mankind.

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; mutagenic effect and chromosomal aberrations of radiation; cancer treatment.

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: Applied and commercial aspect of radiation: radiation information technology; radiation in microscopy and mineralogy; radiation in scanning; radiation in food preservation; radiation as alternative source of energy.

Suggested Readings: (All latest editions)

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