PONDICHERRYUNIVERSITY

School of Life Sciences

DEPARTMENT OF ECOLOGY & ENVIRONMENTAL SCIENCES

CURRICULUM FOR M.Sc. PROGRAM IN ENVIRONMENTAL SCIENCES

2023-24 onward

PONDICHERRY UNIVERSITY
School of Life Sciences
Department of Ecology & Environmental Sciences

Master of Science in Environmental Sciences

PROGRAM OBJECTIVES

The objectives of the MSc Ecology are:

1. to provide students the fundamental concepts and principles of environment

2. to make students aware of the importance of environment and its conservation

3. to introduce the modern tools and techniques available to study and understand the environment

4. to teach field techniques, sample collection, mapping and analysis

5. to make students to take up research and teaching in environmental sciences

PROGRAM OUTCOME

The students will

1. understand the concepts and principles of environment

2. understand the structural and functional aspects of environment and the need for its conservation

3. Be familiar with modern tools and techniques and their appropriate use to conduct research.

4. Be aware of the suitable use of field techniques, sample collection, mapping, analysis and interpretation.

5. Be able to take up research and teaching in environmental sciences.

ELIGIBILITY

- Bachelor's degree in Science with a minimum of 55% marks.

PONDICHERRY UNIVERSITY
School of Life Sciences
Department of Ecology & Environmental Sciences
Curriculum for
M.Sc. Environmental Sciences
2023-2024 onwards

Total Credit for Hard Core courses = 52
Total Credit for Soft Core courses = 20
Total Credit requirements =72

SOFT CORE COURSES – ENVIRONMENTAL SCIENCES

ENVIRONMENTAL CHEMISTRY

EVNS 401 CREDITS- 4

COURSE OBJECTIVES: To make students aware of Fundamentals of Environmental Chemistry and basic concepts of air, water and soil chemistry. Knowledge of Chemistry of organic and inorganic pollutants and green chemistry will help them to pursue their future research on these areas.

UNIT-I Fundamentals of Environmental Chemistry: Mole Concept, Solution Chemistry, solubility product, Solubility of gases, Classification of elements, Stoichiometry, Laws of thermodynamic- first, second and third, Stereochemistry Gibbs' energy, chemical potential, chemical kinetics, chemical Equilibrium, solubility of gases in water, Henry's law, unsaturated and saturated hydrocarbons Acid-base reactions. Sources of natural and artificial radiations, Applications and handling of isotopes and other radionuclides in the environment. **[10 hours]**

UNIT-II Chemical compositions of Air: Classification of elements, chemical speciation, Particles, Ions and radicals in atmosphere, chemical processes for formation of inorganic and organic particulate matter, Major and trace gases in the atmosphere; Physical and chemical attributes of aerosols, thermo-chemical and photochemical reaction in atmosphere, Oxygen and Ozone chemistry, chemistry of air pollutants, Tropospheric oxidation-reduction processes, smog formation; stratospheric and surface ozone, acid rain. Role of hydrocarbons, oxides of sulphur and nitrogen, halogens in the atmosphere. **[10 hours]**

UNIT-III Chemistry of water and soil: Water chemistry: Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odor, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, carbonate system in water, redox reactions, eutrophication. Soil Chemistry: Physio-chemical composition of the soil, humus, Inorganic and organic components of soil, nutrients (NPK) in soil, the significance of C:N ratio, Cation exchange capacity (CEC), Reactions in soil solution. **[10 Hours]**

UNIT-IV Chemistry of organic and inorganic pollutants: Hydrocarbons: Chemistry of hydrocarbon decay, environmental effects, effects on macro and microorganisms. Surfactants: Cationic, anionic and non-ionic detergents, modified detergents. Pesticides: Classification, degradation, analysis, pollution due to pesticides – DDT and Endosulfan. Heavy metals: Toxic effects of Cd, Pb & Hg. **[10 Hours]**

UNIT-V Green chemistry and green technology: New trends in green chemistry, Basic principles, Atom economy concept and its environmental importance. Green reagents, Green solvents, Green synthesis and Green technology, minimization of energy consumption. **[10 Hours]**

UNIT-VI Environmental Chemistry practical: Sample preparation methods: Types & calibration of standards for soil & water analysis. Chemical analysis of water & waste water; Analyses of wastes & solids; Air & gas analysis; Analysis of heavy metals (Hg, Pb, Cd).Spectrophotometry methods of estimation of Nitrate and Phosphate. **[10hours]**

Text Book:

1. De, A. K. 2017. Environmental Chemistry, New Age International.
2. Stanley Manahan and Stanley E. Manahan. 2009. Environmental Chemistry. 9th Edition, CRC Press
3. R. Gopalan. 2020. A Laboratory Manual For Environmental Chemistry. ISBN: 9789389583588. Dreamtech Press. Wiley.

Recommended Reading:

1. Ruth Ann Murphy. 2022. Environmental Chemistry in the Lab. ISBN 9780367438951. CRC Press
2. Foth, H.D. 1991. Fundamentals of Soil Science. 8th edition. Wiley press
3. Gole, G.A. 2016. Text book of Limnology. 5th edition. Waveland Pr. Inc. Press.
4. Sharma, B.K. and Kaur, H. 1996. Environmental Chemistry-Sharma & Kaur, Goel PublishingHouse.
5. Lancaster M. 2002. Green Chemistry: An Introductory Text, RSC Publishing, UK.
6. Clark J. H. and Macquarrie, D. J. 2002. Handbook of Green Chemistry and Technology, Wiley-Blackwell, UK.
7. Willard & Others, 1988, Instrumental Methods of Analysis, Wadsworth

COURSE OUTCOME: Students will acquire fundamental knowledge of chemistry on various components and their interactions with human environment. In addition student can also understand the green chemistry and its significance

ENVIRONMENTAL POLLUTION AND MITIGATION

EVNS: 402 **CREDITS: 4**

COURSE OBJECTIVES: To impart students the different types of pollution, causes and mitigation strategies.

UNIT-I Air-Natural and anthropogenic sources of pollution. Primary and secondary pollutants. Transport and diffusion of pollutants. Gas laws governing the behaviour of pollutants in the atmosphere. Methods of monitoring and control of air pollution, SO2, NOx, CO, SPM. Effects of pollutants on human beings, plants, animals, materials, and climate. Acid Rain, Air quality standards. **(10 Hours)**

UNIT-II Water-Types, sources, and consequences of water pollution. Water quality standards, Sewage and wastewater treatment and recycling, Human use of surface and ground waters, Ground water pollution. Nanotechnology in wastewater management. Soil Pollution control. Industrial waste effluents and heavy metals, their interaction with soil components. Soil micro-organisms and their functions, degradation of different insecticides fungicides and weedicides in soil. Different kinds of synthetic fertilizers (NP &K) and their interactions with different components of soil. **(10 Hours)**

UNIT-III Solid Wastes-Sources and generation of solid waste, Different methods of disposal and management of solid wastes (Hospital wastes and Hazardous wastes) Recycling of waste materials. Waste minimization technologies. **(10 Hours)**

UNIT-IV Noise-Sources of noise pollution measurement of noise and indices, Effect of meteorological parameters on noise proposition. Noise exposure levels and standards. Noise control and abatement measures. Impact of noise on human health. **(10 Hours)**

UNIT-V Marine-Ocean pollution by toxic wastes Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system-coastal management. Radioactive pollution radioactive waste and radioactivity from nuclear reactors and Thermal Pollution. **(10 Hours)**

UNIT-VI Determination of SPM in ambient air by high volume sampler and an air quality survey report of an area. Water quality analysis: determination of DO, BOD and COD. Solid waste: estimation, composition and segregation. Measurement of noise of different sources using sound meter. Survey of a coastal beach for plastic and micro plastic pollution. **(10 Hours)**

Text Books:

1. Ruth Ann Murphy. 2022. Environmental Chemistry in the Lab. ISBN 9780367438951, CRC Press.
2. Spellman, F. R, 2021. The Science of Environmental Pollution, 4th Edition, CRC Press.
3. Mitra, S., Patnaik, P., Kebbekus, B. B., 2019. Environmental Chemical Analysis, Second Edition, CRC Press Taylor & Francis Group.
4. Rieuwerts, J, 2015. The Elements of Environmental Pollution, Routledge Taylor & Francis Group, UK.
5. Hill, MK, 2010. Understanding Environmental Pollution, Cambridge University Press, UK

Reference Books:

1. R. Gopalan. 2020. A Laboratory Manual for Environmental Chemistry. ISBN: 9789389583588. Dreamtech Press, Wiley.
2. Brusseau, M, Pepper, I, Gerba, Charles 2019. Environmental and Pollution Science, 3rd Edition, Elsevier Publication.
3. Rana, S. V. S. 2011. Environmental Pollution: Health and Toxicology. Alpha Science International Limited.
4. Pillai, P. R. S., 2009. A Comprehensive Laboratory Manual for Environmental Science and Engineering. New Age International (P) Ltd. Publishers, New Delhi.
5. Leonard, K. L., 1995. Pollution Prevention and Waste Minimization in Laboratories, 1st Edition. CRC Press, ISBN 9780873719759.

Web source:

https://cpcb.nic.in/Website of Central Pollution Control Board, New Delhi, India.

COURSE OUTCOME: The students will be aware of the types of pollutants, sources, impacts and mitigation practices

STATISTICAL ECOLOGY AND RESEARCH METHODOLOGY

EVNS 403 **CREDITS: 4**

COURSE OBJECTIVES: To introduce the statistics for ecological and environmental data analysis.

UNIT-I Basics of Scientific research and methodology. Framing a scientific question in ecology and review of literature. Stating the hypothesis and types of hypotheses: null hypothesis and alternate hypothesis. Experimental design and collection of data. Variables- types of variables including discrete and continuous variables. Sample distribution, level of significance, Type-I and Type II errors. Accuracy Vs Precision. Significant figures. Population and sample, Population parameters; Environmental sampling design - Methods for selecting sampling locations and times; Different techniques of sampling – simple random sampling, stratified random sampling, systematic sampling and errors in measurement. **(10 Hours)**

UNIT-II Central tendency- concept; arithmetic mean, geometric mean, mode, median for ungrouped and grouped data. Data dispersion and concept of standard deviation. Variance. Standard Deviation Vs Standard error. Probability Rules and Theoretical Distributions: Basic probability rules, expectation, conditional probability; Probability distributions – Binomial, Poisson, Normal distributions. Skewed data and data transformations (log, square root and arcsine). **(10 Hours)**

UNIT-III Parametric test and Non-parametric tests. Null hypothesis and uses of t- test, F-test, X^2-tests; Test of significance of large samples. Correlation and Regression: Bi-variate data and scatter diagram; Simple (linear) correlation and regression; Coefficient of correlation and regression and their properties; Fitting of regression line; Multiple and partial correlations and regressions. **(10 Hours)**

UNIT-IV Parametric tests: Student's t test (paired and unpaired t test). Analysis of Variance: Different types of models used in ANOVA; Basic assumptions and its violation; Application of ANOVA to environmental data. Distribution- Normal, t and chi square test; Difference among means: F-test: One-way ANOVA and multiple ANOVA (MANOVA), Posthoc tests (Tukey test). **(10 Hours)**

UNIT-V Non-parametric tests: Wilcoxon test, Mann-Whitney U-test, Kruskal and Wallis test, Friedman test and posthoc tests (Nemenyi test). Computer applications in environmental modeling, Computer based modeling for population and population studies. **(10 Hours)**

UNIT-VI Multivariate data analysis, hypothesis testing Model fitting; Matrices, simultaneous linear equations; tests of hypothesis and significance; Multidimensional Scaling, Principal Component Analysis, Canonical Correspondence Analysis using software like PAST, Statistica, SPSS. **(10 Hours)**

Text books:

1. Zar, Jerrold H. (2010). Biostatistical Analysis. 5th Edition, Pearson Publication.
2. Sokal RR and Rohlf FJ (2009) Introduction to Biostatics, 2nd Edition, Dover Publications, Inc, New York.
3. Walpole, R. and R. Myres (1993). Statistics for Engineers and scientists, 5th edn. Mac Millan, N.Y.
4. Bhujel Ram C. (2011). Statistics for Aquaculture. John Wiley and Sons.

Reference Books:

1. Wayne, R. Ott (1995). Environmental Statistics and Data analysis, CRC Press.
2. Manly (2001) statistics for environmental science and management, Chapman and Hall/CRC Press

COURSE OUTCOME: The students will be able to select appropriate statistical tool and to do statistical analysis on a proper dataset.

ENVIRONMENTAL LAW &POLICY

EVNS: 404 **CREDITS: 4**

COURSE OBJECTIVES: To make students aware of Indian as well as International environmental laws and policies that governs pollution, water, air, soil, wildlife, forest, toxic substances, environmental impact analyses and environmental risk.

UNIT-I International Environmental Laws and Conventions: Evolution and Development on International Environmental Laws with references to Stockholm Conventional on Persistent Organic Pollutants, Convention on Biological Diversity (Cartagena Protocol and Nagoya Protocol), CITES, UNFCCC, Bonn Convention, RAMSAR Convention, Rotterdam Convention on the prior informed consent for certain hazardous chemicals and pesticides in international trade; Vienna convention for the protection of the ozone layer **(10 Hours)**

UNIT–II Environmental Laws and Policies in India: Constitutional and Statutory laws in India - Doctrine Principles of State Policy, Fundamental duties and Fundamental Rights and Panchayat Raj System. Provision of Constitution of India regarding Environment (Article 48A and 58A). The Environment (Protection) Act, 1986; The Water Act, 1974; The Air Act, 1981; Relevance of 1988 forest policy to country's developmental policies/initiatives. Forest (Conservation) Act, 1980 and rules. The Wildlife (Protection) Act, 1972, the Wildlife (Protection) Amendment Act, 2022 and National Wildlife Action Plan. Biodiversity Act. 2002; Intellectual Property Rights (IPR) Act. Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA); Public Liability Insurance Act, 1991; The National Green Tribunal Act, 2010; Biological Diversity Act, 2002 and rules. **(10 Hours)**

UNIT–III Environment and Development: Mainstreaming biodiversity conservation into developmental sectors; Importance of critical review of plan with respect to local, regional& immediate & long term gains &effect of development. Comparison between a exploitation and safe guard for conservation, b. rate of utilisation and regeneration, c. natural and manmade growth, d. survival need of mankind and protection of Environment Integration of development with carrying capacity of environment Case study of current issue. **(10 Hours)**

UNIT–IV National Environmental Policy: National Policy on EIA and Regulatory Framework: Rule & regulation of central & State Government and Central & State pollution control boards for Safeguard for Environment Protection. Cumulative Environmental Impact Assessment (CIA), Strategic Environmental Assessment (SEA) **(10 Hours)**

UNIT–V Sustainable Development: Definition and concepts of Sustainable development, Integration of: a. Economic, Social and Environmental sustainability, b. Biodiversity and c. Availability of natural resources in development. Cost benefit analysis. Kunming-Montreal Global Biodiversity Framework, 2022. India's National Biodiversity Strategy and Acton Plan (NBSAP). **(10 Hours)**

UNIT–VI United nation Convention on Desertification; Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; International Plant Protection Convention

(IPPC). Rule & regulation & guidelines given for disposal of hazardous waste, municipal solid wastes & bio-medical waste. **(10 Hours)**

Text Books

1. Leelakrishnan, P. (2016). Environmental law in India. LexisNexis.
2. Dwivedi, O. P. (2016). India's Environmental Policies, Programmes and Stewardship. Springer.
3. McGuire, C. J. (2014). Environmental Law from the Policy Perspective: understanding how legal frameworks influence environmental problem solving. Routledge.

Reference Books

1. Divan S, Rosencranz A. (2021). Environmental law and Policy in India. Oxford University Press, Second Edition.
2. Bell, S., McGillivray, D., Pedersen, O., Lees, E., & Stokes, E. (2017). Environmental law. Oxford University
3. Jacob I. Bregman, Robert D. Edell, Environmental Compliance Handbook, 2016, Lewis Publications

Web source

https://moef.gov.in/en/Website of Ministry of Environment, Forest and Climate Change, Government of India
https://cpcb.nic.in/Website of Central Pollution Control Board, New Delhi, India
https://rural.nic.in/enWebsite of Ministry of Rural Development, Government of India

COURSE OOUTCOME: Students will know the national and international environmental laws, national environmental policy and sustainable development.

ENVIRONMENTAL BIOTECHNOLOGY

EVNS 411 **CREDITS: 4**

COURSE OBJECTIVES: This course aims to introduce fundamentals of Environmental Biotechnology and focuses on the utilization of plants and microbial processes in waste and water treatment, and bioremediation. The environmental applications of biotechnology will be taught in detail with examples from the national and international literature.

UNIT- I Concept of Environmental Biotechnology - Definition - concept and scope - Application of biotechnology; Role of microbial systems - Principles – Characteristics; Genetically engineered organisms - Merits and demerits; Biopharming; Bio tools for environmental monitoring; Role of biotechnology in environmental protection. **(10 Hours)**

UNIT-II Biotechnology and pollution abatement - Biotechnology in wastewater treatment - Bioreactors – Types of bioreactor, design of bioreactor;Microbial system in waste water stabilization - Biofilms immobilization technology in waste water treatment; Microbial metabolism and growth kinetics- oil degradation- biodecolourization- Biofiltration and Bioindicators; Bio-flocculation; Microbiology of degradation of xenobiotics. **(10 Hours)**

UNIT- III Role of Biotechnology in Bioremediation - Bioremediation - fundamentals, methods and strategies of application (biostimulation, bioaugmentation) - examples, bioremediation of heavy metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.); Technological aspects of bioremediation (*in situ, ex situ*). Role of microorganims in bioremediation- Application of bacteria and fungi in bioremediation; Phytoremediation - Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization). **(10 Hours)**

UNIT- IV Biotechnology and value addition - Bio processes in waste treatment- Production of value added products from waste - single Cell Protein (SCP), Mushroomculture, vitamins and enzyme production from wastes, Biogas, Bioethanol, Biodiesel, Biohydrogen, Biodegradable plastics - Biofertilizers - Biopesticides- Biopreservatives, Biopolymers. **(10 Hours)**

UNIT- V Environmental Monitoring - Definition and environmental monitoring process; Sampling- land, water, air; Bioindicators (living organisms)- Biomarkers (general & specific) - Biosensors (pesticides, heavy metals, phenolics etc.,) - Biomonitoring in polluted environment. **(10 Hours)**

UNIT-VI Environmental sample analyses - Electrophoretic Techniques: Theory and application of Polyacrylamide and Agarose gel electrophoresis; Native and SDS-PAGE electrophoresis; Native PAGE for enzyme deduction; Isolation and estimation of chlorophyll by UV-spectrophotometry;

Determination of dissolved oxygen (DO) concentration of water sample by Winkler's method; Determination of biological oxygen demand (BOD) in sewage sample; Determination of chemical oxygen demand (COD) of polluted sample. **(10 Hours)**

Text Books

1. Parihar, 2008, Environmental Biotechnology: Fundamentals and Applications, Agrobios Publisher, ISBN No.)10):81-7754-344-X; ISBN No. (13) 978-81-7754-344-5
2. Thakur, 2019, Environmental Biotechnology, 2ed: Basic Concepts and Applications, Dreamtech Press, ISBN-10 : 9389307554; ISBN-13 : 978-9389307559
3. Patra et al., 2020, A Practical guide to Environmental Biotechnology, Springer Nature Singapore, ISBN: 9811562512, 9789811562518
4. Dutta et al., 2011, Experimental Biotechnology: Practical Manual Series 06, ISBN: 9789380235721

Reference Books

1. Environmental Biotechnology: Theory and Applications, G. M. Evans and J. C. Furlong (2003), Wiley Publishers.
2. Pandey, A., Negi, S., Soccol, C.R., "Current Developments in Biotechnology and Bioengineering: Production, isolation and purification of industrial products", Elsevier, 2016.
3. Miller Jr. G.T., 2004. Environmental Science. Tenth Edition. Thompson Brooks/Cole. Unit ed States.
4. ToonikaRinken, State of the Art in Biosensors - General Aspects, ISBN 978-953-51-1004-0, First published March, 2013
5. WIT Transactions on State of the Art in Science and Engineering, Vol 30, © 2008 WIT Pres www.witpress.com, ISSN 1755-8336 (on-line)

Suggested Web Pages

1. https://www.biotecharticles.com/Category-23/0/Environmental-Biotechnology.html
2. https://www.nature.com/articles/s41598-020-62737-x

COURSE OUTCOME: Postgraduate students will apply the concepts of Biotechnology in Environmental Management. They can able to demonstrate and apply their knowledge of biochemistry, microbiology and molecular biology to solve the problems related to the field of biotechnology. Students will also be able to put on the principles of various bioprocess in the design, analysis, optimization and simulation of bioprocess operations.

NATURAL RESOURCES MANAGEMENT

EVNS 412 **CREDITS: 4**

COURSE OBJECTIVES: To understand the source and availability of various natural resources, causes for the degradation of natural resources, the basic principles of natural resource management.

UNIT-I Definition and classification of natural resources; Historical perspective and perception-human population growth, technological revolution and socio economic transformation and natural resource consumption. Fossil fuels-classification, composition, physiochemical characteristics, energy content of coal, petroleum and natural gas. Reserves of oil and gas, Environmental implications of energy use, CO_2 emissions, global warming, air and thermal pollution.

[10 Hours]

UNIT-II Natural resources and Exploration and Exploitation of natural Sources: Sun as source of energy, solar radiation and its spectral characteristics: photovoltaic energy conversion, types of photovoltaic systems. Wind, geothermal energy; nuclear energy-fission and fusion; bioenergy-energy from biomass and biogas. **[10 Hours]**

UNIT-III Principles of generation of hydroelectric power, Ocean- Thermal Energy Conversion, Oceans a new areas of exploration of mineral resources, Environmental impact of exploitation, smelting and processing of minerals, impacts of large scale exploitation of solar wind, hydro and ocean energy; Economics of natural resources.

[10 Hours]

UNIT-IV Causes for the degradation of natural resources: Natural and manmade disasters and human impacts- natural causes; study of Earthquake, Tsunami, Tropical cyclones and western disturbances, Flood, *El nino*, Drought, Landslides, Volcanism and Avalanche. Man-Made causes; Deforestation, Overexploitation, Pollution, Agricultural and aqua cultural intensification, industrialization and land use changes. **[10 Hours]**

UNIT-V Need for natural resource management: Theory of renewability and non-renewability of natural resources, limits of growth, carrying capacity and absorbing capacity of the ecosystems-Mismatch between agricultural productivity rate and renewability rate of natural resources. Natural resources conservation and sustainable development. **[10 Hours]**

UNIT-VI Management strategies for natural resources: Augmentation, substitution and conservation, Individual and community based management strategies-potentials and constrains; Trans boundary natural resources and their management; Water crisis-conservation of water resources, Eutrophication and restoration of Indian lakes, Rain water harvesting, Wetland conservation, wastelands and their reclamation, waste recycling and power generation, Fly ash utilization. **[10 Hours]**

Text Book:

1. Howard C. Hayden, Vales 2015. Energy: A Textbook, Lake Publishing, LLC; First edition;ISBN-10: 0981969445
2. Chiras. D.D, Reganold. J.P, 2009, Natural resource conservation – management forsustainable future, 10th Ed., Pearson publiication. ISBN 978-0132251389.
3. Manoj Kumar Jhariya, Ram SwaroopMeena, Surya Nandan Meena. 2022. Natural Resources Conservation and Advances for Sustainability. Elsevier. ISBN 978-0-12-822976-7.
4. Misra H.N , Harikesh N. Misra. 2014. Managing Natural Resources: Focus on Land and Water. Prentice Hall India Learning Private Limited. ISBN 978-8120349339.

Recommended Reading

1. C. A. Brebbia, M. E. Conti, E. Tiezzi. 2007. Management of Natural Resources, Sustainable Development and Ecological Hazards. WIT Press.
2. Craig. J.R., Vaughan. D.J., Skinner. B.J., 1996, Resources of the Earth: origin, use, and environmental impact, 2nd Ed. Prentice Hall, New Jersey.
3. David A. Anderson 2015. Environmental Economics and Natural Resource Management 4th Edition, ISBN-13: 978-0415640961

COURSE OUTCOME: The students will understand the current scenario and the problems faced by the natural resource users while harvesting the common pool resources and will learn the principles of conservation and natural resource management in detail.

SUSTAINABLE DEVELOPMENT

EVNS: 413 **CREDITS:4**

COURSE OBJECTIVES: To introduce the student to the concept and overview of Sustainable Development across various topics such as environment, energy and ethics at global and national context.

UNIT–I Overview of Sustainable Development: concept and history of sustainability - evolution of sustainable development goals (SDGs) of the United Nations - Stockholm conference – development and environmental initiatives by UNEP – Brundtland commission – ethical implications – dimensions of sustainability – weak and strong sustainability – integrative concepts of sustainability. **(10 Hours)**

UNIT–II Sustainable Land Use and Ecosystem Services: definition and concept of sustainable land use and ecosystem services – concept of value chain - global and national aspects on sustainable land use and ecosystem services – case studies on sustainable development of various land use systems – agroecosystems – agroforestry system. **(10 Hours)**

UNIT–III Environmental and Economic Sustainability: People's perception of the environment - Global and National context of Environmental Impact Assessment – institutional framework for environmental management – Economic sustainability – Global and National context. **(10 Hours)**

UNIT –IV Sustainable Energy Systems: Sustainable Energy – concept and case studies – policy governing energy systems across globe – national policy on sustainable energy – international and region cooperation. **(10 Hours)**

UNIT–V Ethical and Social Sustainable Development: Concept and principles of Ethics – Distribution of Natural Resources – ethical dimension of sustainability – origin of poverty – concept of poverty across world – social inclusive growth – gender equality - NGOs – role of NGOs in sustainable development – Corporate Social Responsibility (CSR) **(10 Hours)**

UNIT-VI Climate Change and Sustainable Development – Climate change as a threat for sustainable development – vulnerable groups – greenhouse gas emission - global warming and challenges for sustainable development. **(10 Hours)**

Textbooks

1. Niko Roorda **2020. Fundamentals of Sustainable Development**, 3 edn..Milton: Taylor & Francis Group
2. Manish K. Verma **2021 Environment and Sustainable Development: Perspectives and Issues**. Milton: Taylor & Francis Group.
3. Baleshwar Thakur, Rajiv R. Thakur, Srikumar Chattopadhyay, Rajesh K. Abhay2021. **Resource Management, Sustainable Development and Governance: Indian and International Perspectives**. Cham: Springer International Publishing AG.

Additional references

1. Godwell Nhamo, Muchaiteyi Togo, Kaitano Dube **2021. Sustainable Development Goals for Society Vol. 1: Selected Topics of Global Relevance**. Cham: Springer International Publishing AG.
2. Godwell Nhamo, David Chikodzi, Kaitano Dube **2021. Sustainable Development Goals for Society Vol. 2: Food Security, Energy, Climate Action and Biodiversity**. Cham: Springer International Publishing AG; 2021.

COURSE OUTCOME: The student would be able to understand the basic concept of Sustainable Development (SD), the environmental, social and economic dimensions; be able to comprehend the conflicts which are involved in the SD concept on the national as well as on the global scale

REMOTE SENSING AND GIS

ECOL: 501 **CREDITS: 4**

COURSE OBJECTIVES: To make students understand the fundamental principles, sensors characteristics and applications of different types of remote sensing. To introduce students the importance of spatial mapping and modeling in GIS for natural resources management. To provide students the various satellite data sets that are freely available in different repository, the procedure to download and processing. It is also aimed to give hands-on practical on geometric correction, preprocessing, classification, accuracy assessment and map composition

UNIT-I Principles of Remote Sensing: Concepts of Remote Sensing, Electromagnetic spectrum – visible, infrared and thermal, microwave regions, effects of atmosphere – absorption, scattering, reflection; Principle of scanner and CCD array, Spectral reflectance of earth's surface features in different wavelength region of electromagnetic spectrum: spectral characteristics of surface features (soil, vegetation, water). (a) Thermal remote sensing: Basic principles, Radiation laws, Sensing radiant energy, Thermal sensors, characteristics of image and their uses. (b) Microwave remote sensing: Basic definitions and principles, advantages, Types of microwave systems - RADAR, SLAR, SAR. **(10 Hours)**

UNIT-II Satellite and Sensors - Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT, IKONOS; Orbital characteristics, Data products. General characteristics, spectral resolution spatial resolution, temporal resolution and radiometric resolution; Digital Image Processing- Principles, Image rectification and restoration, Image enhancement and Mosaicing. Image classification - Supervised, Unsupervised, Ground truth data, Classification accuracy assessment – commission error, omission error and Kappa statistics. **(10 Hours)**

UNIT-III: Air borne and space borne data: Fundamentals of photogrammetry, aerial cameras, planning of aerial photography, principles of stereo-photography, parallax; characteristics of aerial photographs; Elements of image interpretation - visual interpretation of aerial photographs and satellite imageries, instruments used in interpretation. Satellite data availability – United States Geological Survey (USGS), Bhuvan, India, European Space Agency (ESA), National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA). **(10 Hours)**

UNIT-IV Geographic Information System (GIS): Basic principles, components and terminologies, Raster and vector data structure, attribute data, Map projection, Digital cartography, elements of map, thematic map, proximity analysis, overlay analysis, GIS software – commercial and open source, Global Positioning System (GPS) - Basic principles, satellite constellation, control segment and user segment, AGPS and DGPS and applications. **(10 Hours)**

UNIT-V Applications of Remote Sensing and GIS: Forest resources - forest type mapping, forest density mapping, change analysis, matrix analysis; water resources - mapping surface waterbody, flood and inundation mapping; agriculture – crop area and yield estimation, damage detection, plant

disease detection; disaster mapping – forest fire, fire frequency mapping, fire trend analysis, landslide, land use and land cover mapping, land cover dynamics. **(10 Hours)**

UNIT-VI Satellite data downloading from Earth Explorer, Layer stacking, False color composite preparation, Unsupervised classification, Supervised classification, Head-up interpretation, Accuracy assessment, Map composition (**10 Hours**)

Text books

1. Li J., (2021) Satellite Remote Sensing Technologies, Springer Publications.
2. Rees W.G (2013) Physical Principles of Remote sensing (3 rd edition), Scott polar, Research Institute, University of Cambridge, New York.
3. George Joseph (2008) Fundamentals of Remote Sensing (2 nd edition), Universities press, Hyderabad.
4. Lillies T. M. and Kiefer R.W (2003) Remote Sensing and Image Interpretation, John Wiley and Sons.
5. Emery W. and Camps A., (2017) Introduction to Satellite Remote Sensing 1st Edition Atmosphere, Ocean, Land and Cryosphere Applications, Elsevier Publications

Reference books

1. Raizer, V (2017) Advances in Passive Microwave Remote Sensing of Oceans 1st Edition CRC Press
2. Solimini, D., (2016) Understanding Earth Observation: The Electromagnetic Foundation of Remote Sensing (Remote Sensing and Digital Image Processing) 1st Edition, Springer;
3. Estes J. E., and Senger, L.W. (1973), Remote Sensing Techniques for Environmental Analysis, John Wiley and Sons New York.
4. Fischer, and Nijkamp, P (1993). Geographic Information Systems – Spatial Modeling and Policy Evaluation, Springer – Verlag.

COURSE OUTCOME: At the end of the course, students will know about the different types of remote sensing data available and its application in mapping and monitoring the natural resources, Students will also know the potential applications of GIS mapping and modeling in natural resources management. Students will know the different repository from where the relevant satellite data could be downloaded. Students will also have a hands-on experience in satellite data handling, processing, classification and map composition

CLIMATE CHANGE, ADAPTATION AND MITIGATION

EVNS 502 **CREDITS: 4**

COURSE OBJECTIVES: To make students aware of scenario of climate change and to provide exposure on discussions happening at national and international levels

UNIT–I A simple example of global change: stratospheric ozone depletion–impacts and policy responses; A complex example of enhanced greenhouse effect- fundamentals of the climate system– changing composition of the atmosphere from human population growth & activities –climate variability in the last millennium and the recent climate record – future emissions and future climate. **(10 Hours)**

UNIT – II Greenhouse Gases and Climate Change: Introduction to Greenhouse Gases, - Major and Minor Greenhouse gases in the atmosphere - Sources and Sinks - Global Warming - Mitigation Strategies **(10 Hours)**

UNIT III Impacts on earth system and society: Impact- regional, national, global; ecosystems; agriculture and food security; sea level rise; acid rain; ocean acidification, coral bleaching; human health; Forestry and Fishery. **(10 Hours)**

UNIT–IV Understanding Vulnerability: Key concepts of Sensitivity and Vulnerability–Adaptive capacity, Resilience and Coping ranges and Critical Thresholds; Determinants of vulnerability and adaptive capacity; Variations among regions and sectors; Conceptual framework for assessing vulnerability to climate change; Necessity for adaptation to climate variability; Adaptation types and forms-planned versus autonomous adaptation; No-regrets adaptation options. **(10Hours)**

UNIT– V Assessing Impacts and Vulnerabilities: Climate change scenarios and Vulnerability; Methods of Vulnerability Assessment; Indicators of vulnerability and livelihood; Climate sensitivity analysis; Uncertainties in prediction and detection; Vulnerabilities and adaptation practices in forestry, agriculture, soil & land, water resources; Measures for heatwaves, coastal inundation – cities– critical infrastructure; Global Policy on Climate and Adaptation. **(10 Hours)**

UNIT–VI Policy responses and mitigation strategies to a changing planet –Energy options and making decisions; IPCC assessments and scenarios; Kyoto protocol; REDD, REDD+, CDM, International Geosphere and Biosphere Programme (IGBP) and other planned interventions. **(10 Hours)**

Text Books

1. M, Chandramouli and S. Phanindra K.B.V.N. 2018. Water Resources and Environmental Engineering II: Climate and Environment. Rathinasamy, Uma Mahesh.
2. Parry, ML et al. 2007.Impacts, Adaptation and Vulnerability. Climate change. Cambridge University Press.

Reference Books

1. Thomas E. Lovejoy and Lee Jay Hannah 2006. Climate Change and Biodiversity; Published by Yale University Press, 2006ISBN 0300119801, 80300119800 418 pages.
2. William H. Schlesinger 1997. Biogeochemistry: An Analysis of Global Change. Academic Press, San Diego, CA. 2nd edition. Available at the Bay Tree Bookstore.

COURSE OUTCOME: Students would be able to address climate change mitigation and adaptation issue.

ENVIRONMENTAL IMPACT ASSESSMENT

EVNS: 503 **CREDITS: 4**

COURSE OBJECTIVES: To provide theoretical and as well as practical knowledge, to plan and carry out an environmental impact assessment and environmental management plans in compliance with the environmental clearance procedures in India.

UNIT – I Development Projects and Impacts; EIA and types of EIA methods; definition of EIA & EIS. Negative & positive aspects & uncertainties in EIA, Historical synopsis; Approach to EIA studies – mandatory requirements, project screening, scoping. Environmental baselines, best practices, terms of reference. Phases of EIA – Identification, Prediction, Evaluation, Decision Making and Post impact Monitoring the question of Significance; Complexities in environmental measurement; Special issues & concerns for different type of projects with case studies. **(10 Hours)**

UNIT – II Review of methodologies of EIA: Impact Identification Techniques – Checklists, Matrices, Map Overlays, Networks, Leopold Matrix; Environmental Evaluation System; Economic Approaches to EIA (Cost Benefit with market and shadow prices); Ecological Mapping. **(10 Hours)**

UNIT – III National Policy on EIA and Regulatory Framework: Environmental Impact Assessment Notification 2006 and Coastal Zone Notification 1991; Environmental Clearance Process in India; Legislative requirements (discharge requirements and area restrictions); Environmental Appraisal procedure for mining, industrial, thermal power, nuclear power, and multipurpose river valley projects; Role of Central & State pollution control boards in Environmental Protection. **(10 Hours)**

UNIT – IV Environmental, Methods, Risk Analysis-: Definition of Environment Audit & its importance for industries, Requirements of Rule 14 for Environmental Audit under Environmental protection Act 1986, Definitions of a. Signatory, b. Consumption Audit, c. Pollution Audit, d. Hazardous Audit, e. Solid waste Audit, f. Disposal Audit, g. Cost Audit, h. Investment Audit, i. Voluntary Audit. Need & Definition of Risk Analysis, Identification of risk due to project activities, Cost of alleviation of risk & impact on project cost, Disaster Management**.** **(10 Hours)**

UNIT – V Environmental impact Analysis of any Development Project: Public Participation, Preparation of Environmental Management plans (EMPs): Environmental management overview, Environmental management Issues and considerations. Environmental management systems (EMS) – Principles, Elements and Standards of ISO 14001 & ISO18001. (**10 Hours**)

UNIT – VI Case Studies and report preparation: Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, Highway project, Gas pipeline construction project, Municipal Solid waste processing plant, Air ports. **(10 Hours**)

Text Books

1. Hanna, K., (Ed.), 2022. Routledge Handbook of Environmental Impact Assessment, Routledge, Taylor and Francis Group.

2. Glasson. J., 2019. Introduction to Environmental Impact Assessment, 5th Edition, Taylor and Francis.
3. Reddy, A and Mereddy, 2017. Environmental Impact Assessment, 1st Edition, Elsevier Publication.
4. Anji, R M.,2017. Environmental Impact Assessment. Butterworth-Heinemann.
5. Lawrence, D. P., 2003. Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, Inc.
6. Canter L.W., 1996. Environmental Impact Assessment, Mc Graw Hill Publication, New York.

Reference Books

1. Salim M., Zobaidul, K., 2018. Evaluating Environmental and Social Impact Assessment in Developing Countries, Elsevier.
2. Ch. Wood, 1996. Environmental Impact Assessment – A comparative review.
3. Therivel, R., 1996. Methods of Environmental Impact Assessment, Peter Morris.
4. Welsh Office, 1989.Environmental Assessment – A guide to the procedure, DoE.

COURSE OUTCOME: Students will be equipped to identify environmentally sound technologies or policies to resolve environmental problems.

BIOINDICATORS AND ECOREMEDIATION

ECOL: 470 **CREDITS: 4**

COURSE OBJECTIVES: To understand remediation strategies applicable at the ecosystem level and bio indicators of pollution.

UNIT-I Introduction and concept of Eco remediation, indicators and markers significance of remediation for ecological health. Ecoremediation as an option to treat contaminated soils and ground water. Advantages and disadvantages of the process. **(10 Hours)**

UNIT-II Monitoring and management of bioindicators – Identification of representative indicators for various ecosystem/ habitat. Tools and techniques for monitoring of bioindicators. Management of bioindicators: Case studies. **(10 Hours)**

UNIT-III Composting, major types: Open-air systems, enclosed systems, advantages, Vermicomposting: earthworm biology and physiology, end products, process, and characteristics. **(10 Hours)**

UNIT-IV Bio remediation, types of bioremediation, advantages and disadvantages of bioremediation compared to nonbiological processes, intrinsic and accelerated bioremediation; case studies. In situ and Ex situ bioremediation; mineralization vs. partial degradation. Bioremediation of VOCs. Biodegradation of aromatic and polyaromatic hydrocarbons, polychlorinated biphenyls. Heavy metal and oil spill bioremediation, contaminated soil and groundwater remediation. **(10 Hours)**

UNIT-V Phytoremediation, technical characteristics, types of phytoremediation, factors influencing phytoremediation, advantages and disadvantages of phytoremediation, case studies. **(10 Hours)**

UNIT-VI Reclamation of Contaminated Sites - Case studies, Mine site rehabilitation in India, Plants used for dual benefits: Canola case studies for phytoremediation and biofortification in California, Phytoremediation and biodiesel production from Jatropha. **(10 Hours)**

Text Books:

1. Varjani, S. J. (Ed), Agarwal, A. K. (Ed), Gnansounou, E. (Ed), Gurunathan, B. (Ed), 2018. Bioremediation: Applications for Environmental Protection and Management.
2. William Chang (Ed), 2017. Biodegradation and Bioremediation. Syrawood Publishing House.
3. Singh & Tripathi. Springer, 2007. Environmental Bioremediation Technologies.
4. Atlas RM, Bartha R 2000. Microbial Ecology, Pearson Education, Singapore.
5. Alexander Martin 1999. Bioremediation and Biodegradation, Academic Press, NewYork.

ReferenceBooks:

1. Shahnawaz, M.; Sangale, M. K.; Ade, A. B., 2019. Bioremediation Technology for Plastic Waste.
2. Ajay Singh, Owen P Ward, 1999 Applied Bioremediation and Phytoremediation Springer, New York.

3. Mackova, Martina Dowling, David and Macekthomas 2002. Phytoremediation and Rhizoremediation Springer, NewYork.

COURSE OUTCOME: Students will know the appropriate strategies for remediation of contaminated areas.

ENVIRONMENTAL INFORMATICS AND MODELING

EVNS: 462 **CREDITS: 4**

COURSE OBJECTIVES: To introduce the database concepts, data source, spatial data structure, information extraction. To understand the capabilities of spatial database and geographic information system in solving environmental problems.

UNIT – I Introduction to environmental informatics, definition, components, environmental data – air, water, soil, flora, fauna, weather, data variable and sampling, primary and secondary data, spatial and non-spatial data, data sources, data quality and standards**.** **(10 Hours)**

UNIT – II: Data management: Database management system (DBMS) – Hierarchical database management system, network database management system, relational database management system and object oriented database management system; significance of DBMS, data types, data storage, data query and retrieval; spatial data structure – raster data, vector data, advantages and limitations, remote sensing data – satellite data, air borne data, thematic and attribute data, hardware and software requirements. (**10Hours)**

UNIT – III: Information extraction: Resource information extraction from aerial survey – air borne data, space borne data, data collection using global positioning system, topographical maps, climatic data – temperature, rainfall; spatial database creation - thematic maps, definition, types of thematic maps, components of map, scale of map, abstraction, mapping accuracy; digital database creation – scanning and digitization; non-spatial database creation. **(10 Hours)**

UNIT – IV: Analysis and visualization: Data integration, analysis - data input, process, output; data visualization – trend analysis, pattern analysis, data layers – class value/weightage, layer value/weightage; data integration in GIS domain – grid data, cell size, spatial environment; spatial analysis: proximity/buffer analysis, overlay analysis, arithmetic overlay, weighted overlay, Components, structure, organization, maintenance, updating of information system**.** (**10 Hours)**

UNIT – V: Image interpretation of satellite data (Landsat, Sentinel, IRS, MODIS), Thematic layer creation from Survey of India topographical map (Road network, waterbody, settlement, Dat Collection using Global Positioning System (GPS) (**10 Hours)**

UNIT – VI: Practical - Spatial modeling: Environmental suitability modeling for afforestation, environmental vulnerability modeling for forest fire, study of aerosol optical depth, study of greenhouse gas concentration in the atmosphere (**10 Hours)**

Text Books:

1. Bungartz, HJ, Kranzlmuller D and Weinberg, V 2019. Advances and New Trends in Environmental Informatics: Managing Disruption, Big Data and Open Science. Springer Publication. ISBN-13: 978-3030076191.

2. Avouris, NM., and Page, B. 2010. Environmental Informatics: Methodology and Applications of Environmental Information Processing, Springer Publication.
3. Agarwal, S.K., 2002. Eco-informatics, APH Publishing Corporation, 1535 pages, ISBN-13: 978-8176483247.

Reference Books:

1. Paul P. K., Amitava Choudhury, Arindam Biswas, Binod Kumar Singh (Eds.) 2022, Environmental Informatics: Challenges and Solutions 1st ed. Edition, Springer Publications.
2. Coronel, C., Morris, S., Rob, P., 2009. Database Systems: Design, Implementation and Management, 9th Ed., Course Technology, 700 pages, ISBN-13: 978-0538748841.

2. Maguire, D., Batty, M., Goodchild, M., (Eds.) 2005, GIS, Spatial Analysis, and Modeling, Esri Press, 496 pages, ISBN-13: 978-1589481305.
3. Goodchild, M.F., Parks, B.O., Steyaert, L.T., (Eds.), 1993. Environmental Modeling with GIS (Spatial Information Systems) Oxford University Press, USA, 520 pages, ISBN-13: 978-0195080070.
4. Jorgensen, S. E., Chon, T-S., Recknage, F. A., 2009. Handbook of Ecological Modeling and Informatics, WIT Press, 448 pages, ISBN-13: 978-1845642075.

COURSE OUTCOME: At the end of the course, students will be familiar with database management system, spatial database creation, spatial modeling and how to solve environmental problems spatially.

ADVANCED WATER TREATMENT TECHNOLOGIES

EVNS 463 **CREDITS: 4**

COURSE OBJECTIVES: To understand many of the existing unit operations and processes used for water treatment and to study several newer technologies developed for drinking water purification.

UNIT-I Water: introduction, unique physical and chemical properties and its significance, water quality scenario in India, specifications for drinking water (physical, chemical and bacteriological) by Bureau of Indian standards, World Health Organization, packaged drinking water. (**10Hours)**

UNIT-II Water quality parameters-physical,chemical and biological, indicator organisms, testing for coli form bacteria, water sampling and preservation techniques. ` **(10Hours)**

UNIT-III Drinking Water Treatment- pretreatment, sedimentation, coagulation, flocculation, filtration, disinfection- chlorination advantages and disadvantages, chlorination chemistry, break point chlorination, factors affecting chlorination, UV irradiation, ozonation. (**10 Hours)**

UNIT-IV Other treatment technologies- water softening-chemical precipitation and non- chemical precipitation methods, aeration, activated carbon, membrane filtration processes, membrane fouling, reverse osmosis, desalination. **(10 Hours)**

UNIT-V Green technologies-solardisinfection (SODIS), photocatalytic oxidation process forwater treatment-titanium dioxide photocatalysis, point-of-use (POU) home devices for drinking water treatment, introduction to nanotechnology, environmental applications and implications. **(10 Hours)**

UNIT-VI Use of advanced oxidation process (AOP) for the water treatment, Fenton process, Field visit to drinking water treatment plant, observation and report writing. **(10 Hours)**

Text books

1. NALCO, 2016. The NALCO Water Handbook, McGraw Hill Education 4th Edition.
2. Pizzi, NG, and Pizzi N, 2012, Water Treatment Operator Handbook, American Water Works Association, USA.
3. Wastewater Engineering – 2003. Treatment and Reuse. Metcalf & Eddy,Inc.-4thed. Tata McGraw Hill Publishing Company Limited, New Delhi.

References

1. Standard Methods for Examination of Water and Wastewater, 1998. American Public Health Association (APHA), Clesceri, A.E., Greenberg, A.D.Eaton., Washington.
2. Water Quality and Treatment; 2010. A Hand Book on Drinking Water; American Water Works Association and James Edzwald,
3. Nanotechnology- Environmental Implication and Solutions Louis Theodore and Robert G. Kunz, John Wiley &Sons, INC., Publication, 2005.

COURSE OUTCOME: Will help the students to acquire theoretical and practical knowledge on the chemical, physical, and biological processes necessary for designing and managing modern drinking

water treatment plants

DIGITAL IMAGE PROCESSING FOR ENVIRONMENTAL APPLICATIONS

EVNS: 464 **CREDITS: 4**

COURSE OBJECTIVES: To give students a theoretical background and hands-on training in satellite data handling, processing, mapping and analysis.

UNIT-I Satellite data-Introduction -Satellite data downloading from repository (United States Geological Survey, European Space Agency, Bhuvan portal), Data Import/data Export, Band wise layer information, Satellite data format, understanding metadata, layer stacking. **(10 Hours)**

UNIT-II Type of satellite data **-** Study of PAN chromatic satellite data, Multispectral satellite data, Hyper spectral satellite images and elevations data, raster layer information, layer statistics, false color composite creation. **(10 Hours)**

UNIT-III Data Preparation - Geometric correction of scanned maps, Projection and reprojection, Mosaicing, Stitching, Sub-setting/Masking. **(10 Hours)**

UNIT-IV Analysis of spectral characteristics - Spectral reflectance pattern of Vegetation – collecting phenological variation, Soil – spectral reflectance pattern of sand, dry soil and wet soil, Water – spectral reflectance pattern of Shallow water and deep water, Urban - spectral reflectance pattern of buildings, road, other impermeable surfaces. **(10 Hours)**

UNIT-V Satellite data analysis **-** Digital elevation model, Slope and aspect creation, Satellite data band rationing – Ratio Vegetation Index (RVI), Difference Vegetation Index (DVI), Normalized Difference Vegetation Index (NDVI), Soil-adjusted Vegetation Index (SAVI), Soil Wetness Index (SWI) **(10 Hours)**

UNIT-VI Environmental applications Practical - Vegetation mapping and Change analysis, Urban mapping and change analysis, wetland mapping and change analysis, Crop acreage mapping and change analysis. Forest fire mapping and area analysis **(10 Hours)**

Text Books

1. Jensen, JR, 2013. Remote Sensing of the Environment: An Earth Resource Perspective –, 2nd Edition, Prentice Hall.
2. Lillesand, T, and Kiefer, RW. 2008. Remote Sensing and Image Interpretation Sixty Edition, John Wiley & Sons, Inc,

Reference Books

1 ERDAS IMAGINE Field Guide, Erdas Inc., USA, 2021.
2 ERDAS IMAGINE User Guide, ErdasInc, USA, 2021.

COURSE OUTCOME: At the end of the course, students will be well versed in satellite data handling, image processing, mapping and environmental applications.

WASTE MANAGEMENT

EVNS 465 **CREDITS: 4**

COURSE OBJECTIVES: To impart knowledge on the management of solid and liquid wastes from municipal and industrial sources and principles of remedial measures.

UNIT – I Wastes– Classification and Quantification – Solid Waste Management and Disposal: Sources and Generation of Solid Waste – characterization, composition and classification. Hazardous Waste Management: Cyanides, Dioxins, Detergents, Plastics. Waste Minimization approaches – Monitoring and Management strategies. **(10 Hours)**

UNIT – II Recycling of Wastes – Types – sources – composition of waste – recycling of waste for Industrial, Agricultural and Domestic Purposes; Recycling of Metals, Reuse, recovery And reduction of paper and plastics; Recycling in Beverages, Apparel, Leather, Paper, Pulp, Chemical and other industries; Fly Ash utilization. Waste Disposal Methods – incineration, pyrolysis, gasification. Landfilling technology. Medical waste disposal strategies. Strategies for conversion of biodegradable waste into organic fertilizers and fuels. Composting, Vermicomposting and biomethanization. **(10 Hours)**

UNIT – III Radioactive Waste: Sources, half-life of radioactive elements, modes of decay. Low and High-level Radioactive Waste Management – Waste Minimization and Treatment: Vitrification, Synroc, Solidification, Transmutation. Bioremediation of radioactive wastes, Radiation standards. Recovery from radioactive wastes-PUREX. Storage and disposal of radioactive wastes-Surface and deep geological disposal **(10 Hours)**

UNIT – IV Food waste: types, Sources, causes, environmental and economic impact, biochemical composition of food waste, recovery: valuable chemicals from different food waste. Management of food waste: reducing production losses, post-harvest handling and storage, reducing household food waste, prevention and valorisation of food waste, Food banks. Processing of fruits and vegetable waste, milk and dairy waste, meat waste, fish processing waste, sugar and jaggery industrial waste, fruit kernel and oilseed processing waste. **(10 Hours)**

UNIT – V Principles of Bioremediation – Rapid growth and Metabolism- Genetic plasticity – Metabolic pathways for the degradation of xenobiotics– Microbial site characterization – Microbiological methodologies – Standard bio treatability protocols -Principles and mechanisms of biodeterioration -Microbial leaching of metal ores, microbial transformation of antibiotics and steroids-Phytoremediation and plant microbe interaction in organic and inorganic polluted soils - Genetic engineering approaches. **(10 Hours)**

UNIT – VI Aerobic Bioremediation: Bioremediation of Surface Soils: Fate and transport of contaminants in the Vadose zone – Biodegradation in soil ecosystems – Types of soil treatment systems – Bioreactors. Subsurface Aerobic Bioremediation: in situ Bioremediation – in situ Bioventing –in situ treatments of Harbour Sediments and Lagoons. Bioremediation in fresh water and marine systems: Bench and Pilot Scale studies – in situ Bioreactor treatment of sediments – in situ treatment in marine ecosystem. Anoxic/Anaerobic Bioremediation: Anoxic/Anaerobic Processes–

Fermentation, Degradation of xenobiotic – Anoxic/Anaerobic bioremediation of hydrocarbons.

(10 Hours)

Text Books

1. LaGrega,M.D., Buckingham, P.L., and Evans, J.C. 2001. Hazardous Waste Management,),II Ed, McGraw Hill Inc.
3. Baker, K.H. and Herson, D.S. (1994), Bioremediation, McGraw–Hill Inc, New York. [34]

Reference Books

1. Boulding, J. R. (1995), Vadose-Zone and Ground Water Contamination – Assessment, Prevention and Remediation, Lewis Publishers, Tokyo.
2.Tandon, H. L. S. (1995). Recycling of Crop, Animal and Human Waste in Agriculture, Mc Graw Hill Publishing Co.
3. Alexander, A. 1999. Biodegradation and Bioremediation, 2nd Edition, Academic Press

COURSE OUTCOME: Students will have a basic understanding on the management of different types of waste and remedial measures of recycling, reuse and recover from the waste.

RENEWABLE ENERGY

EVNS 466 **CREDITS: 4**

COURSE OBJECTIVES: To enable an understanding of renewable energy in the broadest terms.

UNIT-I Wind energy - Wind energy resources, power in wind, wind turbine design considerations, grid connected wind farms, hybrid power systems, economics of wind power systems, economic analysis methods, wind energy conversion system. **(10 Hours)**

UNIT-II Solar energy – Introduction, Earth's orbit, solar constant and solar spectra, solar angles, collector angles, solar irradiance, photovoltaic energy conversion, types of photovoltaic systems; solar thermal electric power plant - solar thermal systems, environmental impact. **(10 Hours)**

UNIT-III Bio Fuels – Biomass as a source energy, types of biomass, energy content of biomass, harvesting methods of biomass, conversion of biomass, thermos-chemical conversion of biomass, biodiesel production, bioethanol production**,** forest biomass production, forest species, environmental impact resulting from the generation and exploitation of forest biomass. **(10 Hours)**

UNIT-IV Ocean and Small hydro energy systems – Marine energy, understanding the power of marine energy, global development of marine energy, ocean wave energy, ocean tide energy, mathematical modelling of tidal schemes, global environmental impact; low power hydro plants, micro hydro plants. **(10 Hours)**

UNIT-V Energy planning for renewable energy systems -Modern power electronic technology for renewable energy sources, future trends in wind-power technology, power electronics in photovoltaic systems, recent trends in energy storage technologies, power quality instrumentation, regulatory framework, energy resource allocation, region dependent development in energy planning. **(10 Hours)**

UNIT-VI Field visit: Data collection, Analysis and Report submission. **(10 Hours)**

Text Books

1. Buchla, DM, Kissell TE and Floyd TL, 2017, Renewable Energy Systems, Pearson Education.
2. Zobaa, AF and Bansal, RC, 2011 Handbook of Renewable Energy Technology, World Scientific Publishing Co.Pte. Ltd. Singapore.
3. Boyle, 2012, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 3rd Edition.

Reference Books

1. Renewables 2005: Global Status Report: Notes and References Companion Document, REN21 NetworkReport, 2005
2. Khan, 2017, Non-Conventional Energy Resources, McGraw Hill Education, India Pvt Ltd.

COURSE OUTCOME: Students will be able to define the different key renewable energy technologies, will have a broad appreciation of the potential applications for renewable energy technologies and will understand the strengths and weaknesses of the different renewable energy technologie

FUNDAMENTAL OF GEOGRAPHIC INFORMATION SYSTEM

EVNS: 467 **CREDITS: 4**

COURSE OBJECTIVES: This course structured to instruct the students about the fundamentals of Geographic Information systems in general and spatial data capture, data preparation and management and data analysis in particular.

UNIT –I Introduction to GIS – definition, concept and history of developments in the field of information systems, Hardware and software requirements for GIS, Nature of GIS, Data capture and preparation, data manipulation and analysis, data presentation, Maps, data bases **(10 Hours)**

UNIT –II Geographic information and spatial data types – Models and representation of the real world, defining geographic phenomena, types of geographic phenomena, geographic field, data types and values, geographic objects, boundaries computer representation of geographic information, regular tassellations, irregular tassellations, vector representations, triangulated irregular networks, point representation, line representation and area representation, Topology and spatial relationship representation of a field**.** **(10 Hours)**

UNIT –III Data management and processing – spatial data infrastructure, spatial data capture and preparation, spatial data storage and maintenance, spatial query and analysis, spatial referencing and positioning – reference surface for mapping, the geoid and vertical datum, the ellipsoid, local horizontal datum, coordinate system, 2D geographic coordinates, 3D geographic coordinates, 3D geocentric coordinates, 2D Cartesian coordinates, map projection, classification of map projection. **.** **(10 Hours)**

UNIT –IV Data entry and preparation – direct spatial data capture, indirect spatial data capture, digitizing, scanning, vectorization, metadata, data quality, accuracy and precision, positional accuracy, room mean square error, accuracy tolerance, attribute accuracy, temporal accuracy, data preparation, data checks and repairs, rasterization or vectorization, data from multiple sources, differences in coordinate systems, Interpolating discrete data, interpolating continuous data **.** **(10 Hours)**

UNIT –V Spatial data analysis – Classification, retrieval and measurement functions, Neighbourhood functions, Connectivity functions, measurement on vector data, measurement on raster data, interactive spatial selection, spatial selection by attribute conditions, spatial selection using topological relationships. **.** **(10 Hours)**

UNIT –VI Practical- Introduction to QGIS software, Map reading – SOI topographical map, Geometric correction of SOI topographical map, Map Editing – Working with editing tools, Digitization of feature from SOI topographical map, Digitization of feature from Satellite data, Editing Attribute data, Editing map symbols and labels, Map composition. **(10 Hours)**

Text Books

1. Chang, KT, 2017, Introduction to Geographic Information Systems, McGraw Hill Education 4thEditon.

2. Robinson, AH, Morrison, JL, Muehrcke, PC, Kimerling, AJ, Guptill, SC, 2009, Elements of Cartogrphy, 6th Edition, Wiley Publication.
3. Husain, M, 2014, Evolution of Geographical Thought, Rawat Publishing house.

Reference Books

1. Hands-On Geospatial Analysis with R and QGIS https://www.packtpub.com/application-development/hands-geospatial-analysis-r-and-qgis Author: Shammunul Islam Date: November 2018

2. QGIS Tutorials and Tips, downloadable from https://www.qgistutorials.com/en/

COURSE OUTCOME: Students would be familiar with all basic concepts of geographic information system. Students will also know the spatial data structure, data preparation, mapping concepts, spatial data query, and spatial data analysis.

ANALYTICAL TECHNIQUES FOR ENVIRONMENTAL SAMPLE ANALYSIS

EVNS 468 **CREDITS: 4**

Course Objectives & outcome of the course:

The course is designed to:

- Introduce students about different state of the art analytical techniques
- Discuss in details about different technical aspects of the instrumentation.
- Discuss the basic concept about the techniques and detailed applications
- Discuss in details about different trouble shooting of the instrumentation
- Give hands-on training so that they can apply and use the instrumentation and techniques in their future endeavor.

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in the examination.

UNIT I Spectroscopic Techniques: Basic Principles, Instrumentation and applications of: Ultraviolet – visible (UV-VIS) Spectroscopy, Infrared spectroscopy, FT-IR, Atomic Absorption spectroscopy (AAS) – Inductively Coupled Plasma Emission Mass Spectroscopy (ICP-MS). **(10 Hours)**

UNITII Chromatography Techniques: Different types of Chromatography techniques - Basic principle, methodology, application: Thin layer Chromatography, High Performance Liquid Chromatography, Gel permeation chromatography, Ionexchange chromatography, Gas Chromatography. **(10 Hours)**

UNIT III Electrophoresis: Basic Principle, Methodology, Application-Electrophoresis-PAGE, SDS-PAGE, Agarose gel electrophoresis, 2DElectrophoresis, PCR, DGGE.

(10 Hours)

UNIT IV Chromatography Mass spectrometry: Basic Principle, Methodology, Application, Instrumentation- Liquid Chromatography Mass Spectrometry (LCMS), Ion Sources- ESI, APCI, APP; Mass Analyzers- Quadrupole, Time-of-flight, Ion trap; Collision-Induced Dissociation and Multiple-Stage MS; GCMS. **(10 Hours)**

UNIT V Aerobiology sampling methods. Troubleshoot and Discussion the applications of all the above techniques with examples based on published research papers. Hands-on-training- Different types of Chromatography techniques. **(10 Hours)**

UNIT VI Hands-on-training- Spectroscopic Techniques; Electrophoresis; Chromatography Mass spectrometry. Some real samples analysis. **(10 Hours)**

Text Book:

1. Handbook of Thin-Layer Chromatography, 2003. 3rd Edition; Edited By Joseph Sherma, Bernard Fried. CRC Press.
2. HPLC Basics- Fundamentals of Liquid Chromatography (HPLC); Courtesy of Agilent Technologies, Inc.2023
3. Shimadzu fundamental guides to LC-MS. 2023

Reference books

1. Agilent LC-MS primer. 2001.
[http://ccc.chem.pitt.edu/wipf/Agilent%20LC-MS%20primer.pdf]
2. Waters HPLC-UHPLC notebook. 2017.
3. Principles of Gas Chromatography- Physical Methods in Chemistry and Nano Science. 2019. Archer J.P. Martin and Anthony T. James. The Open Courses Library.
4. https://bookauthority.org/books/best-chromatography-books. 2023.

COURSE OUTCOME: On successful completion of the course, the students will be able understand the basics of various complex instrumentation techniques and will be able to handle the various analytical instruments enabling them to perform various quantitative and qualitative analyses of environmental samples.

COASTAL ZONE MANAGEMENT

ECOL 469 **CREDITS: 4**

COURSE OBJECTIVES: To enhance the capacity of students with knowledge on significance of coastal biodiversity and its environments, to ensure sustainable management of coastal resources with respect to sustainable developmental goals

UNIT-I An introduction to ICZM: Definitions- Integration, coastal zones, management, Governance, Integrated Coastal zone management; need, scope, potentials and constraints for ICZM. **(10 Hours)**

UNIT-II Coastal zones and their uses. Land–sea interactions and impacts of climate change, multiple uses of the Coastal zones and conflicts; Coastal settlements- human impacts on the Coastal zones with special emphasis on fishing, Mainstreaming of biodiversity conservation into different developmental sectors along coastal zone. **(10 Hours)**

UNIT-III Coastal and Marine Biodiversity of India. Ecological or Biological Significant Areas. Important Coastal and Marine Biodiversity Areas. Important Marine Mammals and Sea Turtles Areas, Important Bird Areas, Management of Marine Protected Areas. **(10 Hours)**

UNIT-IV Major ICZM concepts, principles and methodologies: Major principles and premises ICZM/ICAM and Coastal Resources Management Programme (CRMP)- Ecological land use/water use planning; An overview of Environmental monitoring - Ecological and Social indicators, Ecological foot prints, EIA, Application of PRA &RRA, Stake-holder analysis, conflict resolution strategies, local knowledge and management systems and integrated systems approach; the coastal commons and their management; Artificial reefs; Co-management; Coastal information management & communication - Basic Principles. **(10 Hours)**

UNIT-V Ecological services and management of different coastal habitats such as mangroves, corals, seagrass beds, lagoons, estuaries, sand dunes, intertidal mudflats, etc. Mainstreaming marine biodiversity conservation into developmental sectors – enhancing blue economy. Recoveries of endangered marine species and their habitats. **(10 Hours)**

UNIT-VI ICZM Legislation, regulations, policies and planning; The Coastal management cycle-issue identification and assessment; Need and scope for evolving participatory, community based/community run ICZM strategies with special emphasis on poverty eradication and gender equity for coastal Biodiversity Conservation/management; Legal principles/regulations to support ICZM; Experiences and case studies from around the world**.** **(10 Hours)**

Text Books:

1. Arthur James and David Menier 2018. Coastal Zone Management: Global Perspectives, Regional Processes, Local Issues. Publisher: Elsevier. ISBN-10: 0128143509.
2. John R. Clark. 2018 Coastal Zone Management Handbook. CRC Press ISBN 9781315139654 - 720 Pages.

Reference Books:

1. Beatley T, D. J Brower &A. K Schwab, 2002. An Introduction to Coastal Zone Management, Second Edition , Island Press, pp. 285.
2. Sivakumar, K., (Ed.) 2013. Coastal and Marine Protected Areas in India: Challenges and Way Forward, ENVIS, Dehradun-248001, India. 368 pp.
3. Frank Ahlhorn, 2017. Integrated Coastal Zone Management: Status, Challenges and Prospects Publisher: Springer Vieweg; ISBN-10: 3658170506 1st ed. 197 pages.

COURSE OUTCOME: Students will have better understanding about the sustainable management of coastal zone and its significance especially with respect to climate change mitigation.

HAZARDOUS WASTE MANAGEMENT

EVNS: 470 **CREDITS: 4**

COURSE OBJECTIVES: To provide an in depth understanding of solid waste and hazardous waste characteristics, management and its impact on environment and human health.

UNIT-I Introduction: Problems and issues of solid waste management, need for solid waste management, sources and types of the solid waste, properties, generation rate, factors influencing generation of the solid waste and sampling of solid waste, elements of solid waste management, Municipal Solid Wastes (Management and Handling) Rules, 2000 and 2016. **(10 Hours)**

UNIT-II Collection and transport of Municipal Solid waste: On-site handling, storage, and processing; collection of solid wastes, Stationary container system and Hauled container systems, layout of collection routes, economy in transportation of waste optimization of transportation routes, processing techniques. **(10 Hours)**

UNIT-III Waste processing and recovery techniques: Waste processing techniques, mechanical volume reduction, chemical volume reduction, incinerators. Recovery of resources, conversion products and energy recovery, recoverable materials, processing, and recovery systems. Biological and chemical conversion technologies: composting, vermicomposting, pyrolysis. Landfills: Evolution of landfills, types and construction of landfills, leachate pollution and control, monitoring landfills, landfills reclamation. (**10 Hours)**

UNIT-IV Hazardous waste management: Sources and characteristics, health impacts and effects on environment. characterization of hazardous waste – TCLP tests-Storage, labelling and handling of hazardous wastes. Hazardous waste manifests and transport. Biomedical waste: sources and characteristics, disposal, E-waste sources and characteristics, methods of handling, recycling, and disposal, Plastic waste: Sources, types, health impacts and effects on environment. Fly ash - sources, composition, and utilization. Case studies. **(10 Hours)**

UNIT-V Hazardous waste processing techniques: Waste minimization options, Hazardous waste technological options-Physical treatment methods and chemical treatment methods, Biological treatment methods. Disposal of Hazardous waste: Hazardous waste landfills, Site selection Criteria, Design and Operation of Hazardous waste landfills, Remediation of hazardous waste disposal sites. **(10 Hours)**

UNIT-VI Estimation and segregation of solid waste. Physical and chemical composition of Municipal solid waste. Determination of volatile solids, Determination of solid waste components in the field, Report preparation of solid waste in an area. **(10 hours)**

Text books

1. Kalamdhad, A. S., Haq, I., 2022. Emerging treatment technologies for waste management, Springer Verlag, Singapore.

2. Romano, G., Marciano, C., Fiorelli, M. S., 2021. Best Practices in Urban Solid Waste Management: Ownership, Governance, and Drivers of Performance in a Zero Waste Framework. Emerald Publishing.
3. Christensen, H. T., 2010. Solid Waste Technology & Management, Wiley, Volume 1 & 2.
4. Tchobanoglous, G. and Kreith, F., 2002.Handbook of solid waste management, McGraw Hill, 2nd Edition.

Reference Books:

1. Pires, A., Martinho, G., Rodrigues, S., Gomes, MI, 2019. Sustainable solid waste collection and management, Springer.
2. Reinhart, R. D. and Townsend, G. T., 1997. Landfill Bioreactor Design & Operation, CRC Press, 1st Edition.
3. Tchobanoglous, G., Theisen and Vigil, 1993. Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw Hill.

COURSE OUTCOME: The students will acquire proficiency in processing technologies and disposal methods for municipal solid waste and hazardous waste generated from a community.

ENVIRONMENTAL TOXICOLOGY, OCCUPATIONAL HEALTH & SAFETY

EVNS 471 **CREDITS:4**

COURSE OBJECTIVES: The course intends to provide a broad understanding on environmental toxicants and its consequence on health. The students can understand the characteristic effect of toxic substances and its metabolism, environmental impact and diseases caused by different toxicants. Toxic effects of heavy metals and pesticides in occupational health and safety can also be learned precisely from this course.

UNIT- I Basics of Environmental toxicology: Definition and divisions of toxicology, scope and importance of toxicology, Principles of toxicology: Classification of toxicants in environment - natural and anthropogenic, their distribution, transport, and fate in the environment: Types of Toxicity- Acute, Subacute and Chronic effects of Toxicants. Dose-Response Relationship -LC50, LD50, EC50. **(10 Hours)**

UNIT- II Toxicity of Environmental pollutants: Toxicity of Persistent Organic Pollutants (POPs)– pesticides, insecticides, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans. Toxicity of heavy metals: Chromium, cadmium, mercury, arsenic, lead, iron. Biohazards: Radioactive substances, fluorides and carbon monoxide. Routes of Entry: Inhalation, Absorption, Ingestion, Injection. Biodistribution, Biomagnification and Biotransformation and excretion of toxic agents. **(10 Hours)**

UNIT-III Systemic toxicology: Toxic response of different body system, Toxicants and their effects on Dermal, Respiratory, Liver, Kidney, Reproductive Organs. Endocrine disrupting chemicals, Mutagens, Teratogens, and Carcinogens: Effects on Cardio-neuro vascular systems. Alteration of DNA, RNA and Protein Metabolism by Toxic substances. **(10 Hours)**

UNIT-IV Toxicity testing: Principles of toxicity testing, Measurements of LDH values. Monitoring approaches - indicator populations and indicator species. Bioassays- *in vitro* and *in vivo*; Biosensors- enzyme based and DNA based; Bioindicators - metabolites, protein induction, cytochrome P450 enzymes, C reactive proteins, MMPs and metallothioneins. **(10 Hours)**

UNIT-V Environmental and occupational health & safety - Definitions, concept and scope, types of occupational hazards (OSHA), occupational hazards and diseases- Pneumoconiosis's, bagassosis, byssicosiss, asbestosis, anthracosis, siderosis, farmer's lungs. Control of toxic materials and protection measures - air, water and soil. Health effects of pharmaceuticals natural products. **(10 Hours)**

UNIT-VI Phytomedicine for the treatment of occupational diseases-Strategies for theprevention of occupational diseases**,** Role of Oxidative Stress and Antioxidants in Liver Diseases, Noise Induced

Hearing loss, Heat stroke, Miner's nystagmus, Case study on woolen industry workers, case study on asthma, health coverage of workers, WHO response **(10 Hours)**

Text Books:

1. Michael et al., Occupational, Industrial, And Environmental Toxicology, Mosby publisher, 1997, ISBN-10 0815139292: ; ISBN-13: 978-0815139294
2. David Baker, Essentials of Toxicology for Health Protection: A handbook for field professionals, OUP UK; 2nd edition,2012, ISBN-10:0199652546;ISBN-13:978-0199652549

Reference Books

1. Essentials of Toxicology, Casarett and Doull's. Second Edn. (2010). Curtis Klaassen and John B. Watkins III. Mc GrawHill
2. Environmental Toxicology – Biological and Health Effects of Pollutants, Ming-Ho Yu, (2004), Second Edition, CRC Press (Taylor & Francis Group).
3. Shaw and Chedwick. (2004), Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis.
4. Buppert, Carolyn CRNP, JD. Occupational Health: Recognizing and Preventing Work-related Disease and Injury, 4th Edition. 2001 Lippincott Williams & Wilkins, Inc.
5. Zakrzewski S.F (2002), Environmental Toxicology. 3rd Edition. New York, Oxford Univeristy Press.

COURSE OOUTCOME: After finishing the study program, the students should have acquired wide academic and applied knowledge in biology with specialization in the field of environmental toxicology. They can also able to resume the most relevant terms, principles, and methods in environmental toxicology.