THE UNIVERSITY OF BURDWAN

SYLLABUS OF TWO YEAR POSTGRADUATE PROGRAMME

IN

ENVIRONMENTAL SCIENCE

Under

Curriculum and Credit Framework for Postgraduate Programme (CCFPP), as per N.E.P. 2020

w.e.f. 2026 – 2027

2- year PG Programme

Semester wise and Course wise Distribution of Credit & Marks under CCFPP as per NEP, 2020

SEM	Course Type	Course Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
I	Major/Core Course	**PG2 ENVS 1011 (400-499)**	**Research Methodology and Ethics**	6	5-1-0	75	60 – 00 – 15
	Major/Core Course	**PG2 ENVS 1012 (400-499)**	**Advance Concepts in Ecology, Evolution, Ethology and Sustainability**	6	5-0-1	75	40 – 20 – 15
	Major/Core Course	**PG2 ENVS 1013 (400-499)**	**Geochemical Processes, Climatic dynamics and Geohazard**	6	5-0-1	75	40 – 20 – 15
	Major/Core Course	**PG2 ENVS 1014 (400-499)**	**Green Chemistry, Waste Management and Genetic Engineering**	6	5-1-0	75	60 – 00 – 15
	Minor Course	**PG2 ENVS 1021 (300-399)**	**Environmental Perspective**	4	3-1-0	75	60 – 00 – 15
	Total			**28**		**375**	
II	Major/Core Course	**PG2 ENVS 2011 (400-499)**	**Biostatistical Analysis and Instrumentation**	6	5-1-0	75	60 – 00 – 15
	Major/Core Course	**PG2 ENVS 2012 (400-499)**	**Advanced Ecotoxicology and Environmental Microbiology**	4	3-0-1	75	40 – 20 – 15
	Major/Core Course	**PG2 ENVS 2013 (400-499)**	**Environmental Biotechnology, Environmental Laws and EIA techniques**	4	3-1-0	75	60 – 00 – 15
	Major/Core Course	**PG2 ENVS 2014 (400-499)**	**Pollution Management and Emerging Environmental Issues**	4	3-0-1	75	40 – 20 – 15
	Minor Course	**PG2 ENVS 2021 (300-399)**	**Contemporary Environmental Issues**	4	3-1-0	75	60 – 00 – 15
	Total			**22**		**375**	

Semester I
PG2 ENVS 1011 [Major/Core]
Total lecture hours:90
Credits:6::Marks:75[I.A.(15)+Th.(60)]
[Research Methodology and Ethics]

Lectures:90 **Credit:6**

Course Objectives:

a. To introduce students to the fundamental concepts, objectives, and significance of research and research methodology.
b. To develop the ability to identify, define, and formulate research problems effectively.
c. To provide knowledge of research design, sampling techniques, and data collection methods.

I. **Research Methodology**: Basic Concept on research methodology: Meaning of Research; Objectives of Research; Motivation in Research; Types of Research; Research Approaches; Significance of Research; Research Methods versus Methodology; Research and Scientific Method; Importance of Knowing How Research is Done; Research Process; Criteria of Good Research; Problems Encountered by Researchers in India. [10]

II. **Defining Research Problem**: Definition of Research Problem; Selecting the Problem; Necessity of Defining the Problem; Technique Involved in Defining a Problem. [5]

III. **Research Design**: Meaning of Research Design; Need for Research Design; Features of a Good Design; Important Concepts Relating to Research Design; Different Research Designs; Basic Principles of Experimental Designs. [10]

IV. **Sampling design**: Census and Sample Survey; Implications of a Sample Design; Steps in Sampling Design; Criteria of Selecting a Sampling Procedure; Characteristics of a Good Sample Design; Different Types of Sample Designs; Selection of a Random Sample; Random Sample from an Infinite Universe; Complex Random Sampling Designs. [10]

V. **Measurement and Scaling techniques**: Measurement in Research; Measurement Scales; Sources of Error in Measurement; Tests of Sound Measurement; Technique of Developing Measurement Tools; Scaling; Meaning of Scaling; Scale Classification Bases; Important Scaling Techniques; Scale Construction Techniques. [10]

VI. **Methods of Data Collection**: Collection of Primary Data; Observation Method; Interview Method; Collection of Data through Questionnaires; Collection of Data through Schedules; Difference between Questionnaires and Schedules; Some Other Methods of Data Collection; Collection of Secondary Data; Selection of Appropriate Method for Data Collection. [10]

VII. **Interpretation and Report Preparation**: Meaning of Interpretation; Need of Interpretation; Technique of Interpretation; Precaution in Interpretation; Significance of Report Writing; Different Steps in Writing Report; Layout of the Research Report; Types of Reports; Oral Presentation; Mechanics of Writing a Research Report; Precautions for Writing Research Reports; Developing Research Projects & Proposals. [15]

VIII. **Publication ethics**: Introduction of philosophy: Definition, Nature and scope, concept, branches; Ethics: Definition, moral philosophy, nature f moral judgements and reactions; Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification an, Fabrication, and Plagiarism (FFP); Redundant publications: Duplicate and overlapping publications, Salami Slicing; Selective reporting and

presentation of data; Publication ethics: Definition, introduction and importance; Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: Definition, concept, problems that lead to unethical behavior and viceversa, types; Violation of publication ethics, authorship and contributorship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals. [20]

Course Outcome:

a. Students will be able to understand and apply various research methodologies and scientific approaches.
b. Students will be able to formulate research problems and design appropriate research plans.
c. Students will gain skills in sampling, data collection, and use of measurement and scaling techniques.

Semester I
PG 2 ENVS 1012 [Major/Core]
Total lecture hours:75
Credits: 6:: Marks:75[I.A.(15)+T.(40)+ P (20)]
[Advance Concepts in Ecology, Evolution, Ethology and Sustainability]

Lectures75 hrs **Credit:5**

Course Objectives:

a. To provide comprehensive knowledge of ecological principles, including environment–population interactions, community dynamics, and ecosystem functioning.
b. To develop an understanding of evolutionary biology, behavioural ecology, and mechanisms shaping biodiversity and species interactions.
c. To introduce concepts of sustainability, conservation, and applied ecology in the context of global environmental challenges and human development.

I. Environment and Population: Climate regulators; Aquatic environment: variation of light, temperature and oxygen; Terrestrial environment: plant cover and light distribution, soil properties influencing life and soil formation; plant adaptation to environment; Animal adaptation to environment; Metapopulation dynamics and Levin's metapopulation model; Mechanism of population equilibrium; Human population growth, expansion and its causes; consequences of population growth; Human demography, promotion and development, demographic transition model; Future of human population. [10]

II. Community ecology: Factors influencing the structure of communities; models of community dynamics, species diversity in communities: measurement and interpretation, landscape dynamics, community restoration, Species interaction, population dynamics and natural selection; Interspecific competition; Prey-Predator interaction; coevolution of prey-predator systems; Host-parasite interaction and population regulation; chaos and limit cycles, community stability. [10]

III. Ecosystem and energetics: Concept of Gaia Hypothesis; Concept of ecosystem; Ecosystem energetics; Ecosystem structure and functional aspects; Decomposition; Ecosystem services-MEA and recent concepts; Distribution of tropical and temperate vegetation at global scale and regulating factors; Lakes, Oceans, Coral reefs; Coastal and wetland ecosystem; Extreme environments: cave, hydrothermal vents, polar regions. [10]

IV. Evolution: History of Evolutionary thought: Lamarckism; Darwinism; Modern Synthesis Fundamentals: Variation; heritability; natural selection; fitness and adaptation; types of selection (stabilizing, directional, disruptive) Diversity of life: Origin and history of life on earth; diversity and classification of life; systems of classification (cladistics and phenetics) Life history strategies: Allocation of resources; tradeoffs; r/K selection; semelparity and iteroparity Interactions: Co-evolution (co-adaptations, arms race, Red Queen hypothesis, co-speciation); Mimicry, crypsis, etc.; Population and Quantitative genetics: Origins of genetic variation; Mendelian genetics; Hardy Weinberg equilibrium; drift; selection (one-locus two-alleles model); population genetic structure (panmixia, gene flow, FST); polygenic traits; gene-environment interactions (phenotypic plasticity); heritability Molecular evolution and phylogenetics: Neutral theory; molecular clocks; rates of evolution; phylogenetic reconstruction; molecular systematics Macroevolution: Species concepts and speciation; adaptive radiation; convergence; biogeography. [15]

V. Behavioural ecology: Classical Ethology: Instinct; fixed action patters; imprinting; learnt

behavior; proximate and ultimate questions Sensory ecology: Neuroethology; communication (chemical, acoustic and visual signaling); recognition systems Foraging ecology: Foraging behaviour; optimal foraging theory Reproduction: Cost of sex; sexual dimorphism; mate choice; sexual selection (runaway selection, good-genes, handicap principle, etc); sexual conflict; mating systems; parental care. Social living: Costs and benefits of group-living (including responses to predators); effect of competition (scramble and contest) on group formation; dominance relationships; eusociality; kin selection; altruism; reciprocity; human behavior. [15]

VI. Sustainability and applied ecology: Invasive species; endemism; conservation genetics (genetic diversity, inbreeding depression); DNA fingerprinting and DNA barcoding disease ecology and evolution: epidemiology; zoonotic diseases; antibiotic resistance; vector control plant and animal breeding: marker assisted breeding; genetic basis of economically important traits. Large scale patterns of biological diversity; IPP and IPR in conservation; global climate change: Important drivers, impact on ecosystem, mitigation pathways; Net-zero emission; Sustainable development goals and its application in aquaculture, agriculture, industry, urban system, forestry and renewable resources; global and national strategies on sustainable development. [15]

Course Outcomes:

a. Students will be able to explain ecological processes, population dynamics, and ecosystem structure and functions.
b. Students will analyze evolutionary mechanisms, behavioural adaptations, and biodiversity patterns using scientific approaches.
c. Students will apply ecological and conservation principles to address real-world issues such as climate change, biodiversity loss, and sustainable development.

Semester I
PG 2 ENVS 1012 [Major/Core] Practical
Total hours:30
Credit:1::Marks:20
[Practical on Environment and Ecology]

Practical : 30 hrs **Credit : 1**

Course Objectives

a. To acquire hands-on experience in measuring and analyzing oxygen profiles and biotic components of aquatic ecosystems
b. To collect, observe, and identify pond biota, including plankton and macrophytes, and apply staining techniques for microscopic analysis
c. To conduct physicochemical analyses of water and soil, and essential soil nutrients, and interpret environmental quality
    1. Measurement and preparation of Oxygen Profile in aquatic ecosystem
    2. Estimation of abundance: Quadrate counts, line transects and distance method
    3. Spatial pattern analysis and indices of dispersion
    4. Determination of species diversity by diversity indices
    5. Lay out of experimental design (RBD; split-plot etc.,); Cluster analysis; Sampling techniques and statistical analysis of experimental design
    6. Study of pond biota – phytoplankton, zooplankton and macrophytes diversity; and staining of plankton
    7. Soil parameters: Electrical Conductivity (EC), Bulk density and Particle density, Porosity and Texture, Cation Exchange Capacity (CEC)
    8. Laboratory Note book
    9. *Viva-voce*

Course outcomes:

a. Measure and interpret the oxygen profile of aquatic ecosystems and relate it to ecosystem health and productivity
b. Identify and analyze phytoplankton, zooplankton, and macrophytes in freshwater systems, and apply staining techniques for enhanced observation
c. Students will learn and analyze key soil parameters

Semester I

PG 2 ENVS 1013 [Major/Core]
Total lecture hours:75
Credits: 6:: Marks:75 [I.A.(15)+Th.(40)+ Pract. (20)]
[Geochemical Processes, Climatic dynamics and Geohazard]

Lectures 75hrs **Credit:5**

Course Objectives

a. To develop a strong foundation in geochemical processes, including element distribution, geochemical cycles, and hydrogeochemistry with emphasis on environmental issues.
b. To provide knowledge of climatological principles, atmospheric processes, climate systems, and climate change dynamics.
c. To introduce geohazards, their causes, impacts, risk assessment, and mitigation strategies in the context of environmental management.

I. Geochemical Processes

Geochemical classification of elements; Abundance of elements in bulk Earth, crust, hydrosphere and biosphere; Partitioning of elements during surficial geologic processes; Geochemical recycling of elements; Paleoclimate; Hydrogeochemistry: The aquifer geochemical system; solution, redox, and gas exchange processes; Water/rock interaction; geochemistry of contaminant mobility (Fluoride, arsenic in Indian context) [25]

II. Climatology

Elements of climate: Earth's radiation balance, latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation; Earth's thermal environment and seasons; Coriolis force, pressure gradient force, frictional force, geo-strophic wind field, gradient wind. Climates of India, western disturbances, Indian monsoon, *El Nino*, *La Nina*, ENSO,QBO; Classification of climate-Koppen's and Thornthwaite' scheme.

Climate change - past and future; Atmospheric stability diagrams, turbulence, diffusion, mixing height, specific gas constant, adiabatic and iso entropic processes, dry and moist air parcel, thermodynamic diagram (T- phigram); Influence of stability on stack effluents; Topography and plume, plume rise, dispersion of plume. [25]

III. Geohazards

Introduction to Geohazards: Definition and classification of geohazards; historical examples of environmental and societal impacts of geohazards; Geological processes leading to geohazards (e.g., earthquakes, volcanoes, landslides). Seismic and Volcanic Hazards: Seismic hazards: Earthquake mechanisms, fault systems, and assessment of risk; Tsunamis: Definition, causes of tsunami generation, propagation and warning systems, impact and mitigation; Volcanic hazards: Types of volcanoes, volcanic eruptions, monitoring, and prediction. Mass Movement Hazards: Landslides and slope stability: Introduction, factors contributing to landslides, types of landslides, rockfall and rockslides, methods for slope stability assessment and mitigation measures for landslides and slope stabilization; Coastal and riverine hazards: Coastal erosion and sea-level rise, flooding (riverine and flash floods), coastal protection and flood management strategies. Climate Change and Geohazards: The impact of climate change on geohazards; Predicting future geohazard risks in a changing climate; Geohazard monitoring, early warning systems, and disaster preparedness. Geohazard Risk Assessment and Mitigation: Geohazard risk assessment: Quantification, risk matrices, and modelling; Geohazard mitigation strategies: Building design, land use planning, and disaster management. [25]

Course Outcomes:

a. Students will be able to explain geochemical cycles, element behavior, and groundwater geochemistry in environmental contexts.
b. Students will analyze climatic processes, atmospheric dynamics, and interpret climate variability and change.
c. Students will evaluate geohazard risks and apply appropriate mitigation and disaster management strategies.

Semester I
PG 2 ENVS 1013 [Major/Core] Practical
Total hours:30
Credits:1::Marks:20
[Practical on Climatology and Geohazard assessment and Green Chemistry]

Practical : 30 hrs **Credit : 1**

Course Objectives

a. To develop practical skills in handling climatic datasets, statistical analysis, and graphical representation of meteorological parameters.
b. To provide hands-on experience in climatological tools, indices calculation, and interpretation of atmospheric data and diagrams.
c. To introduce field exposure, disaster management analysis, and sustainable practices such as biofuel and eco-friendly material production.

i. Retrieval of climatic dataset (IMD/NOAA)
ii. Computation of mean, median, standard deviation; Rainfall Variability Index; Coefficient of Variation
iii. Preparation of isohyetal, isotherm and isobar map
iv. Draw and interpret wind roses to understand prevailing wind directions and frequencies (Indian Context)
v. Time series analysis of temperature and rainfall (Linear and Moving average)
vi. Calculation of Potential Evapotranspiration (PET) and Moisture Index as per Thornthwaite's scheme.
vii. ENSO, El Niño, La Niña and QBO indices calculation, diagrammatic representation, and interpretation.
viii. Interpretation of T-φ gram/Tephigram
ix. Visit to an automated weather station
x. Case study on disaster risk mitigation project
xi. Critical review of disaster management plan of a State, District and City
xii. Preparation of Biodiesel from Vegetable/Waste Cooking Oil
xiii. Bio-fabrics from weeds

Course Outcomes:

a. Students will be able to analyze climatic data using statistical techniques and prepare thematic maps and diagrams.
b. Students will interpret atmospheric processes, climate indices, and time-series data for understanding climate variability.
c. Students will apply practical knowledge in disaster risk assessment, environmental sustainability, and field-based observations.

Semester I

PG 2 ENVS 1014 [Major/Core]
Total lecture hours:90
Credits:6::Marks:75[I.A.(15)+Th.(60)]
[Green Chemistry, Waste Management and Genetic Engineering]

Lectures:90hrs **Credit:6**

Course Objectives

a. To introduce the principles of green chemistry, sustainable practices, and environmentally friendly technologies in chemical processes.
b. To provide comprehensive knowledge of solid, hazardous, and electronic waste management, including treatment, recycling, and disposal techniques.
c. To develop understanding of genetic engineering, environmental mutagenesis, and their applications in pollution control and resource conservation.

I. **Green chemistry and Sustainability**: Need for emergence of green Chemistry, Chemistry in everyday life, Concept of green chemistry, Twelve Principles of Green Chemistry, Greener solvents [Water, Supercritical Fluids (SCFs), Ionic Liquids, Liquid Polymers, Bio-Based Renewable Solvents], Concept, green catalyst; Material life cycle and application of green chemistry; chemical reactions; Rate of reaction, rate law, adsorption chemistry- physisorption and chemisorption, adsorption-isotherms, organic compounds – hydrocarbons and polymer chemistry; Biological chemistry – chemistry of carbohydrate, nucleic acids, enzymes. Earth friendly plastics: Plastics-the Biggest Source of Pollution, Greening of Plastics, Environmentally Benign Pesticides: Effect of Synthetic Pesticides on Human Health and Environment, Search for Environmentally Benign Pesticides [Microbial Pesticides, Plant-pesticides, Biochemical Pesticides], Natural Home-made Solutions for Pest-control, chemistry of green hydrogen, hydrogen as renewable fuel. [15]

II. **Solid Waste** - types and sources; Solid waste characteristics; generation rates, solid waste components, proximate and ultimate analyses of solid wastes. Solid waste collection and transportation: container systems - hauled and stationary, layout of collection routes, transfer stations and transportation. Municipal solid wastes, biomedical, hospital, sewage, agricultural, industrial and mining wastes; Solid waste processing and recovery – Recycling, recovery of materials for recycling and direct manufacture of solid waste products. Composting, vermicomposting, pyrolysis, biomethanation; Electrical energy generation from solid waste (Fuel pellets, Refuse derived fuels), biomethanation of solid waste. Disposal of solid wastes – sanitary land filling and its management, incineration of solid waste. [20]

III. **Hazardous waste** – Types, characteristics and health impacts. Hazardous waste management: reduction and recycling; Treatment Methods – neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal; waste to energy ; valorization . [15]

IV. **e-waste**: classification, methods of handling and disposal. [5]

V. **Fly ash and Plastic waste**: Sources, composition and utilization of fly ash; Plastic waste- sources, consequences and management; Microplastics; microbeads-sources, occurrence and distribution; types and classification; environmental effects and toxicity. [10]

VI. **Principle of genetic engineering**: Concept, cell cycles: molecular mechanism, gene cloning; genetics responses of microorganisms with reference to pollutants; GMO and its merits and demerits; Conservation of gene resources; Recombinant DNA technology and its applications and limitations; Nif gene and biological nitrogen fixation. [15]

VII. **Environmental mutagenic and genetic disorders:** Mutagenesis mechanism: UV-induced (cyclobutane type pyrimidine dimmers), single strand DNA breaks, chemical induced DNA alkylation, abduct formation, intra- and inter-strand cross-linking; Enzyme mediated photorepair and excision repair. [10]

Course Outcomes:

a. Students will be able to explain green chemistry concepts and apply sustainable approaches in chemical and environmental systems.
b. Students will analyze different types of waste, evaluate management strategies, and propose effective waste treatment and resource recovery methods.
c. Students will understand genetic engineering techniques, assess environmental mutagens, and evaluate their impacts on ecosystems and human health.

Semester I

PG 2 ENVS 1021 [Minor]
Total lecture hours:60
Credits:4::Marks:75 [I.A.(15)+Th.(60)]
[Environmental Perspective]

Lectures:60 hrs **Credit:4**

Course Objectives:

a. To develop understanding of environmental issues, ethics, climate change, and sustainable environmental practices.
b. To provide knowledge of medical geology, environmental health, and the role of microorganisms in diseases and environmental interactions.
c. To familiarize students with environmental regulations, public health systems, and waste management practices in India.

I. Environmental Issues: Basic ideas on ecosystem and community; Environmental issues; Conservation and environmentalism; Environmental ethics and philosophy; Environmental education; Ecofeminism, environmental agenda; Concept on climate change and its conventions. [10]

II. Medical Geology: Perspectives and concepts; Geological sources of nutrients, mineral elements needed for good health; Dietary sources of essential mineral elements; Pathways and exposure with reference to arsenic and fluoride in groundwater. [10]

III. Emerging contaminant pollution, health implications: Micro- and nano-plastics (MNPs), Pharmaceuticals and personal care products, Per- and poly-fluoroalkyl substances (PFAS), Endocrine-disrupting chemicals (EDCs), Sources and pathways of PPCPs in the environment, Environmental and health implications, Routes and health effects of EDCs introduction in the environment. [10]

IV. Environmental Health and Diseases: Concept on health and diseases; Principle of communicable and non-communicable diseases; Chemicals in food-preservatives, artificial sweetening agents, elementary idea of antioxidants, antibiotics, antacids; Health programmes in India; Hospital waste management. [10]

V. Medical Microbiology: Concept of pathogens; Infection and intoxication; Epidemics & Pandemics; Causative agents, symptoms, mode of transmission, prevention and treatment. [10]

VI. Environmental regulations: Constitutional provisions and Rules & Regulations; Statutory boards of pollution control, *viz*., CPCB, SPCB, Green Tribunal. [10]

Course Outcomes:

a. Demonstrate an understanding of ecological concepts and contemporary environmental issues, and critically evaluate ethical perspectives including ecofeminism and environmentalism
b. Explain the role of geological factors in human health, particularly the health impacts of naturally occurring elements like arsenic and fluoride, describe the characteristics, transmission, and control of microbial diseases, and assess strategies for managing epidemics and pandemics
c. Identify major communicable and non-communicable diseases and describe the impact of environmental and chemical factors on human health, including hospital waste and food safety practices.Interpret environmental laws, policies, and the roles of regulatory bodies such as CPCB, SPCBs, and the National Green Tribunal, in safeguarding environmental and public health

Semester II
PG 2 ENVS 2011 [Major/Core]
Total lecture hours:90
Credits:6::Marks:75[I.A.(15)+Th.(60)
[Biostatistical Analysis and Instrumentation]

Lectures:90 hrs **Credit:6**

Course Objectives

a. To provide a strong foundation in statistical concepts, biostatistics, and their applications in biological and pharmaceutical research.
b. To develop skills in data analysis, hypothesis testing, regression modeling, and experimental design using statistical tools and software.
c. To introduce advanced analytical techniques and instrumentation used in research, industrial applications, and clinical trials.

I. **Basics of Statistics**: Statistics, Biostatistics, Frequency distribution; Descriptive statistics- Tabulation, variance, population variance, sample variance, Graphical representation of data; Measures of dispersion- Dispersion, Range, standard deviation, Pharmaceutical problems; Non-parametric Method: Signed-ranked test Kruskal-Wallis test. Mann-Whitney test. Spearman Rank Correlation. Pearson correlation, Multiple correlation – Pharmaceuticals. [15]

II. **Application of statistics in Biology Population and sample**: Sampling distribution, discrete and continuous distribution, Normal distribution. Introduction to probability. Types of Data, Types of groups, one sample, two samples, and more than two samples**;** Hypothesis testing: Types of testing, type I error, type II error, One tail and two tail, power of testing, effect size (Cohen's D) ;Study design and determination of Sample size: Factors associated with sample size determination, Calculating sample size for single group experiment, for continuous variables, for repeat studies. Various study design (observational design, experimental design, etc. [15]

III. **Regression and Probability:** Curve fitting by the method of least squares, fitting the lines y= a + bx and x = a + by, Multiple regression, standard error of regression - Pharmaceutical Examples**;** Probability**:** Definition of probability, Binomial distribution, Normal distribution; Poisson's distribution, properties – problems; Sample, Population, large sample, small sample, Null hypothesis, alternative hypothesis, sampling, essence of sampling, types of sampling, Error-I type, Error-II type, Standard error of mean (SEM) - Pharmaceutical examples; Inferential Statistics : What is inferential statistics ? Parametric Method One-sample t-test, two-sample t-test, paired t-test. Least Significance difference, One-way ANOVA, Two-way ANOVA ANOVA on ranks. [15]

IV. **Non Parametric tests:** Wilcoxon Rank Sum Test, Mann-Whitney U test, Kruskal-Wallis test, Friedman Test; Graphs**:** Histogram, Pie Chart, Cubic Graph, response surface plot, Counter Plot graph; Designing the methodology**:** Sample size determination and Power of a study, Report writing and presentation of data, Protocol, Cohorts studies, Observational studies, Experimental studies, Designing clinical trial, various phases; Application in research- Need for research, Need for design of Experiments, Experiential Design Technique, plagiarism. [15]

V. **Regression modeling:** Hypothesis testing in Simple and Multiple regression models; Introduction to Practical components of Industrial and Clinical Trials Problems**:** Statistical Analysis Using Excel, SPSS, MINITAB®, DESIGN OF EXPERIMENTS, R - Online Statistical Software's to Industrial and Clinical trial approach; Blocking and confounding system for Two-level factorials. [10]

VI. **Design and Analysis of experiments:** Factorial Design- Definition, 2^2, 2^3 design. Advantage of factorial design; Response Surface methodology- Central composite design, Historical design, Optimization Techniques. [10]

VII. **Instrumentation**: Bomb Calorimetry, Chromatography (Paper Chromatography, TLC, GC and HPLC), Flame photometry, Spectrophotometry (UV-VIS, AAS, ICP-AES, ICP-MS), Electrophoresis, XRF, XRD, NMR, FTIR, GC-MS, SEM, TEM. [10]

Course Outcomes:

d. Students will be able to apply statistical methods to analyze biological and pharmaceutical data and interpret results effectively.
e. Students will design experiments, perform hypothesis testing, and use regression models and statistical software for research applications.
f. Students will understand and utilize modern analytical instruments and techniques for data generation and scientific investigations.

Semester II

PG 2 ENVS 2012 [Major/Core]
Total lecture hours:45
Credits:4::Marks:75[I.A.(15)+Th.(40)+ Pract (20)]
[Advanced Ecotoxicology and Environmental Microbiology]

Lectures: 45 hrs **Credit:3**

Course Objectives:

a. To understand the core principles of ecotoxicology & environmental toxicology, ideas on toxicants, including types of toxicity, dose-response relationships
b. To analyze the biochemical behavior and toxic effects of heavy metals in biological systems, and explore appropriate mitigation and remediation strategies, to study the metabolism and biochemical mechanisms of toxicants including tissues
c. To understand the environmental microbiology in soil, water, food, etc. To understand the implications of some industrial microbiology & biotechnology

I. Ecotoxicology: Fundamentals: Classical, ecotoxicology, and environmental toxicology; Elements and areas of toxicology; Acute and chronic toxicology; Classes of contaminants: Inorganic - Metals & Metaloids, etc., Organic contaminants – hydrochlorofluorocarbons, organochlorine alkanes, polycyclic aromatic hydrocarbons, etc.; Routes of entry of toxicants [7]

II. Metabolism of toxicants: Disposition of toxicants: Absorption, distribution, excretion, *etc.*; metabolism of toxicants: types of metabolic changes, toxication vs. detoxification, factors affecting metabolism, *viz*., chemical, biological factors; biochemical mechanisms of toxicity: Chemical carcinogenesis, tissue lesions like liver, kidney, nerve, multi-organ toxicity, *etc*. [7]

III. Toxicological chemistry of some specific industrial toxicants: Toxic substances & their toxicology: Sources, distribution, mechanism of exposure, effects and remedial measures of some specific toxicants like PTMs (arsenic, cadmium, lead, mercury, aluminium, chromium), MIC, pharmaceutical active compounds (PACs), estrogenic substances, households, etc. [7]

IV. Environmental Microbiology: Microbial flora in soil – biogeochemical role, biochemical transformations like nitrogen, carbon, sulfur and their compounds; aquatic ecosystems – distribution, techniques and role of aquatic microbial ecosystem; microorganisms in wastewater – determination of sanitary quality, wastewater treatment & disposal [7]

V. Microbiology of foods – Sources in food, growth in foods, microbial spoilage & food poisoning, fermented foods, food preservation; food-borne diseases (*Clostridium* sp., *Salmonella* sp., *E. coli*, etc.), microbiological quality of milk, pasteurization; microorganisms as food, e.g., single-cell proteins; food safety & Standard Act (2006) [5]

VI. Industrial microbiology and Microbial transformations – Industrial uses of bacteria, yeasts, molds; major products of industrial microbiology, microbiology & mining Microbial transformations of heavy metals, pesticides and herbicides; Basics and fundamental reactions of metabolism; microbial immobilization and transformation [5]

Course Outcomes:

a. Students will be able to explain the principles of ecotoxicology, including sources, classification, metabolism, and effects of environmental toxicants.
b. Students will analyze the impact of toxic substances and microorganisms on environmental and human health, including food safety and industrial applications.
c. Students will apply knowledge of environmental and industrial microbiology for pollution control, waste treatment, and bioremediation processes.

Semester II

PG 2 ENVS 2012 [Major/Core] Practical

Total hours: 30

Credits:4::Marks:75[I.A.(15)+Th.(40)+ Pract (20)]

[Practical on Ecotoxicological Measurements]

Practical: 30 hrs **Credit : 1**

Course Objectives:

a. To understand the impact of agrochemicals on different types of plants including hydrophytes, xerophytes, and mesophytes
b. To develop practical skills in the analysis of key water quality parameters such as salinity, conductivity, sulfate, phosphate, nitrate-nitrogen, ammoniacal-nitrogen, residual chlorine, sodium, and potassium
c. To assess the effects of pesticides on biochemical constituents of crops, focusing on total sugar and protein content

1. Effect of pesticides and heavy metals on total sugar content/ total protein/ opening and closing of stomata of different crops.
2. Serial dilution technique, plate count of microbes, MPN
3. Measurement of LC_{50}/LD_{50} and safe concentration of toxicants
4. Study on chronic toxicity
5. Study on toxicological biomarkers *viz*., Histopathological, Morphoanatomical (GaSI, GSI, HIS, RLG, Fecundity)
6. Study on toxicological response through biochemical tests *viz*., amylase, lipase, protease activity etc.
7. Laboratory Note book
8. *Viva-voce*

Course Outcomes:

a. Analyze the physiological and biochemical impact of agrochemicals on hydrophytes, xerophytes, and mesophytes
b. Accurately measure and interpret critical water quality parameters that influence ecosystem health
c. Quantify changes in total sugar content in crops exposed to pesticide treatments, linking biochemical changes to ecotoxicological stress. Assess the toxicological effects of pesticides and heavy metals on protein content in plants and aquatic animals, understanding the implications for food safety and ecosystem health

Semester II

PG 2 ENVS 2013 [Major/Core]

Total lecture hours: 60

Credits:4::Marks:75[I.A.(15)+Th.(60)]

[Environmental Biotechnology, Environmental Laws, EIA and Indian Knowledge System]

Lectures:60 hrs **Credit: 4**

Course Objectives:

a. To provide fundamental knowledge of environmental microbiology, including microbial diversity, structure, and their roles in environmental processes.
b. To develop understanding of biotechnological applications such as biosensors, biofertilizers, and pollution control techniques.
c. To familiarize students with environmental laws, international conventions, and environmental impact assessment (EIA) processes and Indian Knowledge System.

I. Microbes in relation to environment: Virus, bacteria, fungi, algae, lichen, protozoa microbial groups; General idea about bacterial morphology -- shape, size, structure; Chemistry and function of capsule, pilus, membrane, cell wall, plasmid and chromosome, replication of bacterial nucleus; fungal morphology; Distinctive properties of virus, nucleic acids, life cycle pattern of bacteriophages bacteriology of water and sewage-Methods for differentiating faecal from Sewage organisms and their characters; Practical utility of viruses- Bioinsecticides, phage typing. [10]

II. Microbial culture techniques and biosensors: Isolation and characterization; Preservation of microorganisms; Microbial growth curves; Gene sequencing and phylogenetic tree analysis; Biotechnological methods**:** Pollution detection and abatement. Biosensors; Enzyme electrode, immobilized cell biosensor, optical biosensor, ISFET based devices, H_2O_2 biosensor, microbial biosensor, gas phase biosensor, nanobiosensor, amphoteric biosensor, environmental application of biosensor. [10]

III. Agricultural biotechnology: Biofertilizer - Types and application in agriculture; Biopesticides; biocomposting; Integrated pest management - concept, technology involved in agriculture and forestry. [5]

IV. Overview of Environmental Laws in India and EIA: Wildlife Protection Act (amendments 2022), Motor Vehicle Act, 1988, The Hazardous and Other Waste (Management and Transboundary Movement)**,** Rules, 2016, The Plastic Waste Management Rules, 2016, The Bio-Medical Waste Management Rules, 2016, The Solid Waste Management Rules, 2016, The e-waste (Management) Rules 2016, The Construction and Demolition Waste Management Rules, 2016, The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000, The Batteries (Management and Handling) Rules, 2010 with Amendments, Coastal Regulation Zones (CRZ) 1991 amended from time to time; National Forest Policy, 1988, National Water Policy, 2002, National Environmental Policy, 2006; Food Safety and Standards Act, 2006; Plant Quarantine (Regulation of Import into India) Order, 2003; EIA techniques and its evaluation of methodologies, EIA and planning and management; Prediction and assessment of impacts on the air, water, soil, and noise environment; Process of reviewing EIA of developmental projects. [15]

V. Environmental Conventions and Agreements: Stockholm Conference on Human Environment 1972, Montreal Protocol, 1987, Conference of Parties (COPs), Basel Convention (1989, 1992), Ramsar Convention on Wetlands (1971), Earth Summit at Rio de Janeiro, 1992, Agenda-21, Global Environmental Facility (GEF), Convention on Biodiversity (1992), UNFCCC, Kyoto Protocol, 1997, Clean Development Mechanism (CDM), Earth Summit at Johannesburg, 2002, RIO+20, UN Summit on Millennium Development Goals, 2000, Copenhagen Summit, 2009. IPCC, UNEP, IGBP. [10]

VI. Indian Knowledge System (IKS) in Environmental Science: Introduction to Indian Knowledge Systems (IKS) and their relevance to Environmental Science, Vedic and Upanishadic perspectives on nature, ecology, and sustainability, Concept of Panchamahabhuta (five elements) and ecological balance, Traditional water conservation systems (e.g., stepwells, tanks, rainwater harvesting), Sacred groves, biodiversity conservation, indigenous and community conservation practices, Sustainable agriculture: Vrikshayurveda, organic farming, and natural farming and agro-ecology, Environmental ethics in Indian philosophies (Buddhism, Jainism, Hinduism), Folk traditions, festivals, and community-based resource management, Integration of IKS with modern environmental management and policy. [10]

Course Outcomes:

a. Students will be able to explain microbial diversity, culture techniques, and their environmental and industrial applications.
b. Students will analyze and apply biotechnological tools such as biosensors and biofertilizers for environmental monitoring and management.
c. Students will evaluate environmental policies, global conventions, and conduct basic environmental impact assessments for sustainable development and gain knowledge on IKS in Environmental Science.

Semester II
PG 2 ENVS 2014 [Major/Core]
Total lecture hours: 45
Credits:4::Marks:75[I.A.(15)+Th.(40)+ Pract. (20)]
[PollutionManagement and Emerging Environmental Issues]

Lectures: 45 hrs **Credit: 3**

Course Objectives

a. To develop comprehensive knowledge of air, water, soil, noise, and thermal pollution, including their sources, impacts, monitoring, and control measures.
b. To provide understanding of environmental standards, national policies, and pollution management strategies in India.
c. To introduce current environmental issues, disaster events, and sustainable resource management practices.

I. Air Pollution: Criteria air pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. Principles and instruments for measurements of (i) ambient air pollutants concentration and (ii) stack emissions. Indian National Ambient Air Quality Standards. Impact of air pollutants on human health, plants and materials. Acid rain. Dispersion of air pollutants. Mixing height/depth, lapse rates, Gaussian plume model, line source model and area source model. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Control of gaseous pollutants through adsorption, absorption, condensation and combustion including catalytic combustion. Indoor air pollution, Vehicular emissions and Urban air quality. [10]

II. Noise Pollution:Weighting networks, measurement of noise indices (Leq, L10, L90, L50, LDN, TNI). Noise dose and Noise Pollution standards. Noise control and abatement measures: Active and Passive methods. Vibrations and their measurements. Impact of noise and vibrations on human health. [5]

III. Water Pollution:Types of water pollution. Impact on humans, plants and animals. Measurement of water quality parameters: sampling and analysis for pH, EC, turbidity, TDS, hardness, chlorides, salinity, DO, BOD, COD, nitrates, phosphates, sulphates, heavy metals and organic contaminants. Drinking water treatment: Coagulation and flocculation, Sedimentation and Filtration, Disinfection and Softening. Wastewater Treatment: Primary, Secondary and Advanced treatment methods. Common effluent treatment plant. [5]

IV. Soil Pollution: Physico-chemical and biological properties of soil (texture, structure, inorganic and organic components). Analysis of soil quality. Soil Pollution control. Industrial effluents and their interactions with soil components. Soil micro-organisms and their functions - degradation of pesticides and synthetic fertilizers. [5]

V. Thermal, Marine Pollution and Radioactive: Heat Islands, causes and consequences. Methods of Abatement of Marine Pollution. Coastal management. Radiation exposure and radiation standards, radiation protection. [5]

VI. National Action Plan and Policies (National missions) : National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a'Green India', National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change); Viksit Bharat; Emerging mineral reservoirs [5]

VII. Current Environmental Issues in India: Environmental issues related to water resource projects - Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu & Kashmir, Himachal and North-Eastern States**;** Water conservation-development of watersheds, Rain water harvesting and ground water recharge; National river conservation plan – Namami Gange and Yamuna Action Plan; Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India; Soil erosion, reclamation of degraded land, desertification and its control. Environmental Disasters: Minnamata Disaster, Love Canal Disaster, Bhopal Gas Disaster, 1984, Chernobyl Disaster, 1986, Fukusima Daiichi nuclear disaster, 2011; Present Cyclonic events-Aila, Umphun etc., Highrise buildings, Urban and rural sanitation in India, Urban slums [10]

Course Outcomes:

a. Students will be able to analyze different types of pollution, their measurement techniques, and control technologies.
b. Students will evaluate environmental policies, standards, and national action plans for pollution mitigation and sustainable development.
c. Students will assess real-world environmental problems, including disasters and resource management issues, and propose appropriate solutions.

Semester II
PG 2 ENVS 2014 [Major/Core] Practical
Total hours: 30
Credits:1::Marks:75[I.A.(15)+Th.(40)+ Pract (20)]
[Practical on Emerging Environmental Pollution]

Practical : 30 hrs **Credit: 1**

Course Objectives:

a. To provide hands-on experience in environmental sampling and monitoring of air, water, and soil.
b. To develop skills for identification and analysis of microplastics and microbial populations in different environmental matrices.
c. To familiarize students with techniques for measuring environmental parameters such as noise levels in compliance with standards.

i. Microplastics identification
ii. Collection, isolation and population study of microorganism in air, water and soil
iii. Ambient air sampling, monitoring and analysis
iv. Measurement of noise level by dB meter in different zones (as per CPCB guidelines)
v. Laboratory Note book
vi. *Viva-voce*:

Course Outcomes:

a. Students will be able to collect, isolate, and study microorganisms from air, water, and soil samples.
b. Students will be able to identify and quantify microplastics in environmental samples.
c. Students will measure, analyze, and interpret ambient air quality and noise levels following standard guidelines.

Semester II
PG 2 ENVS 2021 [Minor]
Total lecture hours:60
Credits:4::Marks:75[I.A.(15)+Th.(60)]
[Contemporary Environmental Issues]

Lectures: 60 hrs **Credit: 4**

Course Objectives:

a. To provide knowledge of global and national environmental issues, including climate change, biodiversity loss, and ozone depletion.
b. To develop understanding of national missions, policies, and sustainable development initiatives in India.
c. To familiarize students with environmental disasters, forest and wildlife conservation efforts, and strategies for sustainable habitat and resource management.

I. **Global Environmental Issues** : Biodiversity loss, Climate change, Ozone layer depletion. Sea level rise. International efforts for environmental protection. [5]

II. **National Action Plan and Policies (National missions)** : National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a'Green India', National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change); Net-Zero Emission; Viksit Bharat. [10]

III. **Current Environmental Issues in India:** Environmental issues related to water resource projects - Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu & Kashmir,

Himachal and North-Eastern States**;** Water conservation-development of watersheds, Rain water harvesting and ground water recharge; National river conservation plan – Namami Gange and Yamuna Action Plan; Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India; Soil erosion, reclamation of degraded land, desertification and its control. [15]

IV. **Climate change and sustainable habitat**: Adaptability, energy security, food security and sustainability; Carbon sequestration and carbon credits; Swachha Bharat Abhiyan; Sustainable Habitat: Green Building, GRIHA Rating Norms; Current policies of Government of India on renewable resources. [10]

V. **Forest Conservation**: Major movements-Chipko, Appiko, Silent Valley and Gandhamardhan. People Biodiversity register; Wild life conservation projects: Project tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision. [10]

VI. **Environmental Disasters**: Minnamata Disaster, Love Canal Disaster, Bhopal Gas Disaster, 1984, Chernobyl Disaster, 1986, Fukusima Daiichi nuclear disaster, 2011; Present Cyclonic events-Aila, Umphunetc. [10]

Course Outcomes:

a. Students will be able to analyze global and national environmental challenges and their ecological, social, and economic impacts.
b. Students will evaluate government policies, national action plans, and conservation programs for promoting sustainability.
c. Students will assess environmental disasters, forest conservation movements, and wildlife protection projects, and propose strategies for mitigation and sustainable management.