M.Sc. ENVIRONMENTAL SCIENCE
PROGRAM EDUCATIONAL OBJECTIVES

To provide the science graduates with a high level of technical expertise in Environmental Science so that they are able to successfully apply the knowledge to

- recognize the processes that influence the magnitude and routes of exposure to environmental agents, factors, and stressors of chemical, physical, biological and ergonomic origin that pose adverse effects.
- Assess the potential environmental impact of development projects and design mitigation measures
- apply the scientific principles, instrumentation, and techniques to adequately evaluate exposures to environmental agents, factors, or stressors
- organize and interpret environmental data using qualitative and quantitative methods
- recommend, operate and evaluate controls to avoid, reduce or eliminate pollution
- conduct research to identify, abate, and eliminate hazards that affect people, wildlife, and their environments.
PROGRAM OUTCOMES

By the time of their graduation, the students are expected to be able to:

- Understand the physical, chemical and biological components of Earth’s environment, the ecological concepts, principles, processes including human and natural disturbances that impact the environment.
- Assess the potential environmental impact of development projects and design mitigation measures.
- Design and conduct experiments, as well as to analyze and interpret data through laboratory and field exercises.
- Interpret and apply applicable and emerging environmental regulations, standards, and best practices.
- Apply the scientific knowledge and analytical skills to protect environmental resources effectively.
- Monitor waste disposal sites, preserve water supplies, and reclaim contaminated land and water to comply with environmental regulations.
- Design and conduct experiments, as well as interpret data and communicate effectively.
- Find professional level employment or pursue higher studies.
### CURRICULUM I TO IV SEMESTERS (FULL TIME)

#### M.Sc. ENVIRONMENTAL SCIENCE

**SEMESTER I**

<table>
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<th>SL.NO.</th>
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## ELECTIVES

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OBJECTIVES:

- To impart knowledge on the principles and design of control of indoor/particulate/gaseous air pollutant and its emerging trends
- Control of particulates, NOx, SOx, Hydrocarbons and CO
- Air pollutants and global climate.

UNIT I  INTRODUCTION  10

UNIT II  MEASUREMENT AND MONITORING OF AIR POLLUTION  5
Ambient air sampling systems for particulate and gaseous pollutants – Analysis and Measurement of Particulate and gaseous pollutants, odours, visibility – Air Pollution Monitoring and Surveillance.

UNIT III  AIR POLLUTION MODELLING  10
Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport and Dispersion of Air Pollutants – Modeling Techniques – Air Pollution Climatology.

UNIT IV  CONTROL OF PARTICULATE AND GASEOUS POLLUTANTS  12
Working principles of various types of particulate control equipment – settling chamber, cyclone separators and scrubbers, fabric filters and electrostatic precipitators - Working principles of various types of gaseous pollutant equipment – incineration, absorption, adsorption, condensation and bio filters – Case Studies for Stationary and Mobile Sources.

UNIT V  INDOOR AIR QUALITY MANAGEMENT  8

TOTAL: 45 PERIODS

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:
- Suggest suitable air pollution prevention equipments and techniques for various gaseous and particulate pollutants to Industries.
- Discuss the emission standards.
- Apply control and preventive measures of Indoor air pollutants.
ES8102 MICROBIOLOGY OF ENVIRONMENT

OBJECTIVE:
- To educate the students in the area of air, water and soil microbiology and the applications of microorganisms in wastewater treatment and reclamation of pollutants.

UNIT I INTRODUCTION
Classification and Culturing of microorganisms, Isolation of microorganisms – Pure culture technique – Enrichment culture – Preservation of microorganisms – Identification – Biochemical and Molecular Biology Techniques - Microbial nutrition – Carbon, nitrogen, sulfur – Effective Microbial Solution.

UNIT II MICROBIAL PHYSIOLOGY

UNIT III MICROBIOLOGY OF ENVIRONMENT
Distribution of microorganisms in contaminated sites - soil, air, water – Interaction of Microorganisms - Characteristics – Factors affecting Microbial Population – Algae in water supply systems – Problems and control — Extremophiles – Adaptation and survival.

UNIT IV MICROBIOLOGY OF WASTEWATER TREATMENT

UNIT V APPLICATION OF MICROORGANISMS FOR RECLAMATION
Microorganisms as sources of protein – Biofertilizer – Bacterial, fungal, algal – Biocontrol agents – Enzyme production by microorganisms, chemotherapeutic agents – Redox reactions in Microbial degradation of macromolecules – Soil, water and air.

TOTAL: 45 PERIODS

REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to:
- Acquire knowledge on the distribution of microorganisms in various environment and the mechanisms involved in remediating the pollutants.

ES8103 PRINCIPLES OF SUSTAINABLE DEVELOPMENT

OBJECTIVE:
- To understand the environmental, social and economic dimensions of sustainability and the principles evolved through landmark events so as to develop an action mindset for sustainable development.
UNIT I SUSTAINABILITY AND DEVELOPMENT CHALLENGES


UNIT II PRINCIPLES AND FRAME WORK


UNIT III SUSTAINABLE LIVELIHOOD


UNIT IV SUSTAINABLE SOCIO-ECONOMIC SYSTEMS


UNIT V ASSESSING PROGRESS AND WAY FORWARD


REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to:

- Develop a fair understanding of the social, economic and ecological linkage of human production and consumption.
- Learn to integrate the Rio principles of Sustainable development in decision making and Contribute towards Green Economy.

ES8104 PRINCIPLES OF WATER AND WASTEWATER TREATMENT

OBJECTIVES:

- To educate the students on the principles and process designs of various treatment systems for water and wastewater.
- Introduce unit operations and processes employed in the treatment of water and wastewater.
- Develop an understanding of the characteristics of water and wastewater that must be considered during design of a treatment plant.

UNIT I INTRODUCTION
Pollutants in water and wastewater – characteristics, standards for performance – Selection criteria-types of reactors - Significance and need for treatment- unit operations and unit processes-Legislation.

UNIT II PRINCIPLES OF TREATMENT

UNIT III DESIGN OF WATER TREATMENT PLANTS

UNIT IV DESIGN OF WASTEWATER TREATMENT PLANTS

UNIT V RESIDUAL MANAGEMENT
Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering -mechanical and gravity - sludge drying beds - Sludge disposal.

TOTAL: 45 PERIODS

REFERENCES:
ES8105 SOLID AND HAZARDOUS WASTE MANAGEMENT

OBJECTIVE:
- To impart knowledge and skills in the collection, storage, transport, treatment, disposal and recycling options for solid wastes including the related engineering principles, design criteria, methods and equipments.

UNIT I SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK
- Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, nuclear wastes - lead acid batteries, electronic wastes, plastics and fly ash - Elements of integrated waste management and roles of stakeholders - Financing and Public Private Participation for waste management.

UNIT II WASTE CHARACTERIZATION AND SOURCE REDUCTION

UNIT III STORAGE, COLLECTION AND TRANSPORT OF WASTES
- Handling and segregation of wastes at source - storage and collection of municipal solid wastes - Analysis of Collection systems - Need for transfer and transport - Transfer stations Optimizing waste allocation - compatibility, storage, labeling and handling of hazardous wastes - hazardous waste manifests and transport.

UNIT IV WASTE PROCESSING TECHNOLOGIES
- Objectives of waste processing - material separation and processing technologies - biological and chemical conversion technologies - methods and controls of Composting - thermal conversion technologies and energy recovery - incineration - solidification and stabilization of hazardous wastes - treatment of biomedical wastes - Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment.

UNIT V WASTE DISPOSAL
- Waste disposal options - Disposal in landfills - Landfill Classification, types and methods - site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors - leachate and landfill gas management - landfill closure and environmental monitoring - Rehabilitation of open dumps - landfill remediation.

TOTAL: 45 PERIODS

REFERENCES

OUTCOME:
On completion of the course, the candidate will be able to:

- Understand the characteristics of different types of solid and hazardous wastes and the factors affecting variation
- Define and explain important concepts in the field of solid waste management and suggest suitable technical solutions for treatment of municipal and industrial waste
- Understand the role legislation and policy drivers play in stakeholders' response to the waste and apply the basic scientific principles for solving practical waste management challenges.

MA8153 NUMERICAL AND STATISTICAL METHODS

OBJECTIVE
- To learn about the concept for linear equations, integration, differentiation, statistical methods and hypothesis.

UNIT I SYSTEM OF LINEAR EQUATIONS AND INTERPOLATION (9+3)

UNIT II NUMERICAL INTEGRATION AND ORDINARY DIFFERENTIAL EQUATIONS (9+3)

UNIT III EMPIRICAL STATISTICS (9+3)
Description of discrete and continuous data - Measures of Central tendency and dispersion for grouped and ungrouped data - Skewness and Kurtosis.

UNIT IV ESTIMATION THEORY (9+3)

UNIT V TESTING OF HYPOTHESES (9+3)
Statistical hypotheses - Type I and Type II errors - Tests based on Normal, t, χ2 and F distributions for testing of mean, variance and proportions - Tests for Independence of attributes and Goodness of fit.

TOTAL: 60 PERIODS

REFERENCES:
OUTCOMES:
On completion of the course, the candidate will be able to:

- Understand graphical methods of describing data sets and be able to calculate and interpret numerical descriptive statistical measures.
- Understand the concept of sampling distribution of a statistic and be able to calculate the sampling distribution for simple sampling situations.

ES8111    ENVIRONMENTAL MICROBIOLOGY PRACTICALS

OBJECTIVE:
- To educate and train the students in experiments related to microbiological analysis of air, water, soil and wastewater.

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<td>1.</td>
<td>Study of instruments and equipments used in the Microbiology Laboratory.</td>
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<td>Preparation of culture media</td>
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<td>5.</td>
<td>Isolation and Enumeration of microorganisms from soil</td>
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<td>Identification of bacteria by staining techniques</td>
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<td>Effect of Heavy metals on microbial growth.</td>
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<td>Effect of temperature and pH on growth of microorganisms</td>
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<td>Enumeration of Total coliforms and Faecal Coliforms by MPN technique.</td>
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<td>Detection of Anaerobic bacteria</td>
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<td>Estimation of DNA by spectrophotometer.</td>
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TOTAL : 60 PERIODS
REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to:
- Know the various techniques for the analysis of samples for microorganisms from different environments and also to identify the various microorganisms.

ES8201 CHEMISTRY OF ENVIRONMENT

OBJECTIVE:
- To educate the students in the area of water, air and soil chemistry.

UNIT I GENERAL

UNIT II AQUATIC CHEMISTRY
Transport and transformation of chemicals – Phase Interactions- Sorption- Degradation of food stuffs(carbohydrates, proteins), Detergents, Pesticides, hydrocarbons(aliphatic and aromatic) – Photolysis – Volatility – Classification of elements — Complex formation — Hydrophobic interactions –Chemical speciation.

UNIT III ATMOSPHERIC CHEMISTRY
Photochemical reactions in the atmosphere- Degradation of VOCs– Chemical process for the formation of inorganic and organic particulate matter – Ozone formation and depletion chemistry-Photochemical smog and sulphurous smog.

UNIT IV SOIL CHEMISTRY
Soil classification– Inorganic and organic components of soil –physical and chemical properties of soil- Acid -base and ion exchange reactions-Cation exchange capacity-Salt affected soil-types and remediation.

UNIT V GREEN CHEMISTRY
Principles of green chemistry – Clean synthesis, – Atom economy – Environmental factor ‘E’ and Quotient ‘Q’, mass Index, Nano materials synthesis, properties and application CNTs, TiO2.

TOTAL: 45 PERIODS

REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to:
- Communicate effectively with the chemistry and environmental science communities.
- Outline fundamental and applied aspects of environmental analytical chemistry.

ES8202 CLIMATE CHANGE AND MODELING L T P C
3 0 0 3

OBJECTIVE:
- To introduce the emerging concepts of climate modeling and projecting future climate change, understand data analysis and application.

UNIT I CLIMATE CHANGE AND CLIMATE VARIABILITY

UNIT II IPCC SRES SCENARIOS
Intergovernmental Panel on Climate Change (IPCC) - An Overview - Key Assumptions - Scenario Family - Storyline (A1, B1, A2, B2).

UNIT III GLOBAL CLIMATE MODEL (GCM) AND REGIONAL CLIMATE MODEL (RCM)
Some typical GCMs (HadCM3Q-UK Met Office) - Issues with GCMs - Introduction to RCMs and LAMs - some typical RCMs like PRECIS, SimCLIM, MAGICC/SCENGENE - Advantages and Disadvantages of GCMs and RCMs.

UNIT IV DOWNSCALING GLOBAL CLIMATE MODEL - AN OVERVIEW
Need for downscaling - Selection of GCMs for regional climate change studies - Ensemble theory – Selection of - Ensembles, Model Domain (Spatial domain and temporal domain), Resolution and climate variables - Lateral boundary conditions - Methods of downscaling (Statistical and Dynamical) - examples from each and their limitations.

UNIT V ANALYSIS /POST PROCESSING
a. Model validation - post processing – Introduction to Analysis tools - Ferret, R, Grads, IDL, SPSS, ArcGIS
b. Climate change Impact - Vulnerability assessment – adaptation strategies.

TOTAL: 45 PERIODS

REFERENCES:
OUTCOMES:
On completion of the course, the candidate will be able to:

- Understand the earth climate systems and global warming.
- Understand the impact of climate change on society and the adaptation and mitigation measures of climate change impacts.
- Know the concept of modeling techniques.

ES8203 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

OBJECTIVE:
- To expose the students to the need, methodology, documentation and usefulness of environmental impact assessment and to develop the skill to prepare environmental management plan.

UNIT I INTRODUCTION

UNIT II COMPONENTS AND METHODS FOR EA

UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN

UNIT V SECTORAL EIA

REFERENCES:
OUTCOMES:
On completion of the course, the candidate will be able to:
- Understand the legal requirement for getting environmental clearance for new projects.
- Know the requirements to become EIA consultant.
- To be a part of EIA team to conduct EIA study for various Projects.

ES8204 ENVIRONMENTAL BIOTECHNOLOGY

OBJECTIVE:
- The course provides a basic understanding on biotechnological principles and concepts. Biodegradation of pollutants and the mechanism of biodegradation are outlined. The basics of bioremediation and the methods of bioremediation are also provided. An exposure to cleaner technologies and recombinant technology concepts are also covered.

UNIT I BASIC CONCEPTS AND RECOMBINANT DNA TECHNOLOGY 5
General principles - Environmental Pollution; Types of Pollution; Principles of Recombination and Plasmids DNA Transformation - Recombinant DNA Technology - Polymerase Chain Reactions - Isolating and Cloning Fragments - Concept of Gene Probes - Fundamentals of Cloning - Insertion and Expression of Foreign Genes - Recombinant DNA Techniques in Biotechnology - Applications in Environmental Engineering - Environmental Issues.

UNIT II BIODEGRADATION OF POLLUTANTS 8
Xenobiotic compounds and recalcitrance - Biodegradation of Xenobiotics - adaptation of microorganisms for nutrients removal - microbial systems - degradation of toxic pollutants - hydrocarbons; non halogenated and halogenated - industrial application and concerns - Biological treatment of Waste water – Biotechnology for Solid waste management.

UNIT III MECHANISM OF DETOXIFICATION 8
Environmental fate of organic pollutants – mechanisms of detoxification – oxidation, reduction, and dehydrogenation – Microbial system for Heavy metal accumulation - Biotransformation of metals – Biosorption - Microbial leaching of metals – role of extracellular polymers to detect pollutants.

UNIT IV BIO-REMEDIATION 12

UNIT V CLEANER TECHNOLOGIES 12
Biotechnology in biodiversity conservation – microalgal biotechnology and applications in agriculture - biogas biofuel production using microorganisms - Biomining of Resources – Integrated Waste Management - Biosensors in Environmental Monitoring and Analysis - Biofertilizers - Biopesticides – Bacillus thuringiensis and Integrated Pest Management

TOTAL: 45 PERIODS

REFERENCES:
OUTCOMES:
On completion of the course, the candidate will be able to:

- Have a grasp of the basics of the recombinant DNA technology and its environmental applications.
- Understand the mechanisms behind the biodegradation of environmental pollutants in wastewater and solid waste.
- Have a sound understanding on the bioremediation techniques applied to field and the application of microorganisms on waste and wastewater for useful by products and their use in monitoring pollutants in the environment.

ES8205 ENVIRONMENTAL POLICIES AND LEGISLATIONS

OBJECTIVE:
- To impart knowledge on the policies, legislations, institutional framework and enforcement mechanism for environmental studies.

UNIT I INTRODUCTION TO ENVIRONMENTAL LEGISLATIONS

UNIT II WATER (P&CP) ACT, 1974
Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT III AIR (P&CP) ACT, 1981
Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Air Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986
Genesis of the Act – delegation of powers – Role of Central Government - EIA Notification – Sitting of Industries – Coastal Zone Regulation – Responsibilities of local bodies mitigation scheme etc., Act, CrPC for Municipal Solid Waste Management - Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorisation – Biomedical waste rules – responsibilities of generators and role of Pollution Control Boards

UNIT V OTHER TOPICS
Relevant Provisions of Indian Forest Act, Public Liability Insurance, IPC Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

TOTAL: 45 PERIODS

REFERENCES:
1. CPCB (1997) “Pollution Control acts, Rules and Notifications issued there under “Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi.
OUTCOME:
On completion of the course, the candidate will be able to:
- Understand and take the necessary steps to comply with the requirements of the different environmental legislations in India.

ES8206 ENVIRONMENTAL TOXICOLOGY

OBJECTIVE:
- To impart knowledge on toxicology, risk assessment and remediation.

UNIT I BIOCHEMICAL TOXICOLOGY 12
Toxicants, Distribution, Metabolism of toxicants, sites of action, classification of toxicity – acute and sub-acute toxicity bioassay, Factors influencing toxicity, Elimination of toxicants, Methods of toxicity testing – Evaluation - statistical assessment, sediment toxicity, Bio-chemical markers/indicators, Toxicokinetics, Bioconcentration, Bio-accumulation and Bio magnification in the environment.

UNIT II GENETIC TOXICOLOGY 12
Xenobiotics – Chemical carcinogenesis – Genotoxicity assays – Neurotoxicity, Skin toxicity, Immunotoxicity. Renal toxicity, Endocrine disruptors, hormones, receptors.

UNIT III INDUSTRIAL TOXICOLOGY 8
Toxicity of monomers, solvents, intermediates, products – toxic substrates – Metals and other inorganic Chemicals, Organic Compounds – Persistent chemicals.

UNIT IV RISK ASSESSMENT AND REMEDIATION 8
Procedures for assessing the risk – Risk measurement and Mitigation of environmental disorders – Factors in risk assessment.

UNIT V CASE STUDIES IN RISK ASSESSMENT 5
Pharmaceutical, Petroleum, Carbide industry, Textile and Leather Industry Case study.

TOTAL: 45 PERIODS

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:
- Demonstrate knowledge of main groups of toxins and contaminants
- Understand the basic physical, chemical and biological aspects of environmental toxicology.
- Apply in-depth environmental toxicology knowledge under a range of representative real case studies.
- Choose the tools most suitable to analyze concrete environmental toxicology problems.
OBJECTIVE:
- To educate the student on the various Operation & Maintenance aspects of Common Effluent Treatment Plants.

UNIT I ELEME NTS OF OPERA TION AND MAINTENANCE 10

UNIT II COMMON EFFLUENT TREATMENT PLANTS (CETPS) 8
Operation - disposal of effluent and residues - Constraints - Number and type of contributing units - Plant capacity - Location - Ownership and management - Influent and effluent characteristics - Collection and conveyance system - Effluent treatment plant - Treatment process at CETPs - Case Studies.

UNIT III COLLECTION AND CONVEYANCE SYSTEMS 10
Operation and Maintenance of wastewater collection and conveyance systems - Functions of collection system - Components of collection system - Conduits or pipes - Manholes - Ventilating shaft - Maintenance of collection system - Problems generally faced - Clogging of pipes - Hazards - Precautions - Precautions against gas hazards - Precautions against infections - Devices for cleaning the conduits - Preventive maintenance - Corrective maintenance - Case Studies.

UNIT IV OPERATION AND MAINTENANCE OF PHYSICO-CHEMICAL TREATMENT UNITS 9
Operation and maintenance in screen chamber, Grit Chamber and clarifiers - Operation guidelines for clarifier - Equalization basins - Neutralization unit - Chemical storage and mixing equipment - Chemical metering equipment - Flash mixer - Clarifiers - Operation and maintenance - Start-up and maintenance inspection - Motors and Pumps - Chemical feed systems.

UNIT IV OPERATION AND MAINTENANCE OF BIOLOGICAL TREATMENT UNITS 8
Construction, Operation and Maintenance aspects - Operation and maintenance in activated sludge process, trickling filters, anaerobic digester - Trouble shooting - Planning, Organising and Controlling of plant operations - capacity building, case studies of Retrofitting.

TOTAL: 45 PERIODS

REFERENCES:
OUTCOMES:
On completion of the course, the candidate will be able to:

- Follow safe practices in the laboratory and in plant operations.
- Apply chemical, microbiological, and mechanical knowledge and skills to maintain proper water and wastewater plant operations.
- Apply math and hydraulics skills in proper water and wastewater plant, collection system, and distribution system operations.
- Understand regulations and operate the plant accordingly.

ES8211  ENVIRONMENTAL CHEMISTRY PRACTICALS  L T P C
0 0 4 2

OBJECTIVE:
- To train the students in the laboratory in the determination of pollutants present in air, water, wastewater and soil.

LIST OF EXPERIMENTS

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>List of Experiments</th>
<th>Name of Equipment</th>
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<tbody>
<tr>
<td>1</td>
<td>Calibration of Pipette</td>
<td>Weighing balance</td>
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<tr>
<td>2</td>
<td>Measurement of pH of water &amp; sludge soil sample using pH meter</td>
<td>pH Meter</td>
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<tr>
<td>3</td>
<td>Measurement of Electrical Conductivity of aqueous solution using conductivity meter</td>
<td>Electrical Conductivity Meter</td>
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<tr>
<td>4</td>
<td>Measurement of turbidity of water sample – Nephelometry</td>
<td>Nephelometer</td>
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<tr>
<td>5</td>
<td>Determination of alkalinity of water sample by titrimetry</td>
<td>Titration Method</td>
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<td>6</td>
<td>Determination of hardness of water sample by titrations (EDTA)</td>
<td>Titration Method</td>
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<tr>
<td>7</td>
<td>Determination of chloride of water sample by titrations (Mohr’s method)</td>
<td>Titration Method</td>
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<td>8</td>
<td>Determination of sulphate of water sample using colorimeter</td>
<td>Spectrophotometer/Colorimeter</td>
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<td>9</td>
<td>Determination of phosphate of water sample using colorimeter</td>
<td>Spectrophotometer/Colorimeter</td>
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<td>10</td>
<td>Determination of nitrite of water sample by azo dye method</td>
<td>Spectrophotometer/Colorimeter</td>
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<td>11</td>
<td>Determination of ammonia in waste water sample</td>
<td>Spectrophotometer/Ammonia Distillation Unit</td>
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<td>12</td>
<td>Determination of DO by Winkler’s method</td>
<td>DO Meter</td>
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<td>13</td>
<td>Determination of BOD of wastewater sample</td>
<td>BOD Incubator</td>
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<td>14</td>
<td>Determination of COD of wastewater sample</td>
<td>COD Digester</td>
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<tr>
<td>15</td>
<td>Determination of SO₂ in air by Spectrophotometric method</td>
<td>Spectrophotometer</td>
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<tr>
<td>16</td>
<td>Determination of SPM using High volume sampler</td>
<td>High Volume Sampler</td>
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<tr>
<td>17</td>
<td>Determination of potassium in soil.</td>
<td>Flame Photometer</td>
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<tr>
<td>18</td>
<td>Determination of surface area of activated carbon by acetic acid method</td>
<td>Mechanical Shaker</td>
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<tr>
<td>19</td>
<td>Determination of partition co-efficient of acetic acid between water &amp; CCl₄</td>
<td>Titration Method</td>
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<td></td>
<td>Determination of rate constant of a wastewater treatment method</td>
<td>Titration Method</td>
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**TOTAL: 60 PERIODS**

**REFERENCES:**

**OUTCOME:**
On completion of the course, the candidate will be able to:
- Perform Environmental Quality Measurements.

**ES8301 ENVIRONMENTAL ANALYTICAL TECHNIQUES**

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**OBJECTIVE:**
- To educate the students on the analytical techniques of environmental disturbances with reference to air, water and soil.

**UNIT I INTRODUCTION**
Objectives of monitoring-Monitoring net work, Planning ,system design- Sampling devices, preservation , Sample preparation-Classification of analytical methods– Selection of a suitable method - Reliability of analytical data-Statistical analysis- Quality control and assurance, .

**UNIT II ELECTROANALYTICAL METHODS**
Principle, instrumentation and environmental applications of conductometry, potentiometry, coulometry, Capillary electrophoresis and polarography – Field Instruments.

**UNIT III SPECTROSCOPIC METHODS**
Principle, instrumentation and environmental applications of atomic emission, absorption and fluorescence spectroscopy – Molecular UV, visible, IR spectroscopy and scattering methods.

**UNIT IV CHROMATOGRAPHIC METHODS**
General Theory-Column, Paper and thin layer chromatography (TLC) separation- Principle, instrumentation and environmental applications of GC, HPLC , Ion chromatography and size exclusion chromatography.

**UNIT V OTHER METHODS**
Principle, instrumentation and environmental applications of NAA, XRF, XRD, SEM,TGA and Mass spectrometry, Continuous monitoring analysis – fluorescent analyzer for SO₂, chemiluminescent analyzer for NOx, NDIR for CO, Flow injection analyzer.

**TOTAL: 45 PERIODS**

**REFERENCES:**
3. Roger Reeve,Introduction to Environmental Analysis, John Wiley & Sons Ltd,2002
OUTCOMES:
On completion of the course, the candidate will be able to:

- Identify, formulate, analyse and solve environmental analytical chemistry problems.
- Design and carry out a method of environmental chemical analysis, including instrumental analysis.

ES8302 ENVIRONMENTAL MANAGEMENT SYSTEMS AND AUDITING  L T P C
3 0 0 3

OBJECTIVE:
- To impart an understanding of systems approach to Environmental Management as per ISO 14001 and skills for environmental performance in terms of legal compliance, pollution prevention and continual improvement.

UNIT I ENVIRONMENTAL MANAGEMENT STANDARDS
9

UNIT II PREVENTIVE ENVIRONMENTAL MANAGEMENT
9
Pollution control Vs Pollution Prevention - Opportunities and Barriers – Cleaner production and Clean technology, closing the loops, zero discharge technologies – Four Stages and nine approaches of Pollution Prevention - Getting management commitment – Analysis of Process Steps- source reduction, raw material substitution, toxic use reduction and elimination, process modification –Material balance – Technical, economical and environmental feasibility evaluation of Pollution Prevention options in selected industries – Preventive Environmental Management over Product cycle.

UNIT III ENVIRONMENTAL MANAGEMENT SYSTEM
10

UNIT IV ENVIRONMENTAL AUDIT
8
Environmental management system audits as per ISO 19011- – Roles and qualifications of auditors - Environmental performance indicators and their evaluation – Non conformance – Corrective and preventive actions -compliance audits – waste audits and waste minimization planning – Environmental statement (form V) - Due diligence audit

UNIT V APPLICATIONS
9
Applications of EMS; Waste Audits and Pollution Prevention opportunities in Textile, Sugar, Pulp & Paper, Electroplating, Tanning industry, Dairy, Cement, Chemical industries, etc.

TOTAL: 45 PERIODS
REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:
- Appreciate the elements of Corporate Environmental Management systems complying to international environmental management system standards
- Lead pollution prevention assessment team and implement waste minimization options
- Develop, Implement, maintain and Audit Environmental Management systems for Organizations.

ES8001 ADVANCED OXIDATION PROCESS  L T P C 3 0 0 3

OBJECTIVES:
- Identify the most critical issues and challenges that limit the use of conventional treatment processes in planning, design and operation of modern water and wastewater treatment facilities.
- Thorough understanding of the fundamentals of Advanced Oxidation Processes (AOPs) and also Photochemistry and ozone chemistry, its application to AOPs for the removal of contaminants or the detoxification of contaminated waters
- Develop in-depth knowledge that can be used to devise and design effective AOP treatment systems to meet not only current but also anticipated regulatory requirements, and enhance the independent learning and critical thinking skills.

UNIT I INTRODUCTION 9

UNIT II HETEROGENEOUS PROCESS 9

UNIT III HOMOGENEOUS PROCESS 9

UNIT IV INTEGRATED AOPS WITH OTHER TREATMENT METHODS 9
Coupling of AOPs and biological processes - Comparative studies of photo-initiated AOPs - biodegradability and toxicological studies - Ultrasound process - principles of sonochemistry.
UNIT V INDUSTRIAL APPLICATIONS OF AOPS

Applications of AOPs for COD, VOC reduction and odour treatment wastewater from industries like textile, pharmaceutical and petroleum and petrochemical industry - Removal of micropollutants from aquatic (drinking and wastewaters) and atmospheric environments.

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:
- Apply AOPs to solve pollution problems.
- Comprehend the basic principles of advanced water treatment processes, capabilities/constraints of their application in water treatment and have knowledge on the design and operation of these processes.
- Select an appropriate treatment process for a specific application, and identify appropriate pre-treatment and post treatment schemes, protocols for these processes.

TOTAL: 45 PERIODS

OUTCOME S:
On completion of the course, the candidate will be able to:
- Apply AOPs to solve pollution problems.
- Comprehend the basic principles of advanced water treatment processes, capabilities/constraints of their application in water treatment and have knowledge on the design and operation of these processes.
- Select an appropriate treatment process for a specific application, and identify appropriate pre-treatment and post treatment schemes, protocols for these processes.

ES8002 BIO ENERGY

OBJECTIVE:
- To impart knowledge on principles, technologies and economics of Bio-energy for Energy and environmental conservation.

UNIT I INTRODUCTION

UNIT II BIOMETHANATION

UNIT III COMBUSTION & GASIFICATION
UNIT IV PYROLYSIS & CARBONISATION

UNIT V ECONOMICS OF BIOENERGY

TOTAL: 45 PERIODS

REFERENCES:
1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, ichester, 1984

OUTCOME:
On completion of the course, the candidate will be able to,
- Understand the necessity to go for alternative energy and potential for bioenergy and methods to explore the energy in biological mode.

ES8003 BIODIVERSITY CONSERVATION

OBJECTIVE:
- To provide Knowledge about the importance of conserving biodiversity and approaches followed for mitigating threats through conservation.

UNIT I CONCEPTS OF BIODIVERSITY

UNIT II SPECIATION
Species Formation and Evolution - Types- Mechanism of Speciation- Sympatric- Allopatric Speciation - Species losses- Endemism - Its types, Neo endemism, Paleo endemism - Rare and threatened species.

UNIT III LOSS OF BIODIVERSITY
UNIT IV  CONSERVATION BIOLOGY  

UNIT V  CONSERVATION OF ECOLOGY  

TOTAL: 45 PERIODS

REFERENCES:
2. K.V. Krishnamurthy, “Text Book of Biodiversity” Science Publisher Inc. 2003.

OUTCOMES:
On completion of the course, the candidate will be able to:
- Perform biodiversity analysis in a given habitat.
- To understand and frame conservation measures on new or endangered species in a given habitat.

ES8004  DISASTER MANAGEMENT AND MITIGATION  

OBJECTIVE:
- To impart knowledge on various natural and manmade disasters and the mitigation measures to be followed.

UNIT I  NATURAL DISASTERS  

UNIT II  MAN MADE DISASTERS  

UNIT III  MITIGATION  

UNIT IV  RESPONSE AND RELIEF  
Characteristics, operations and logistics for response and recovery – Medical emergencies – Post disaster review – Disaster Legislation – Resources and Utilization – Cost reduction and effective analysis.
UNIT V
ENVIRONMENTAL ISSUES


TOTAL: 45 PERIODS

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:

- Define and describe disaster management, hazard, emergency, disaster, vulnerability, and risk.
- Identify and describe the types of natural and non-natural disasters and the implications of disasters on environment.
- List and describe the main hazards to which our region is, or may be, Vulnerable.
- Describe briefly how the effects of disasters can be reduced on vulnerable groups.

ES8005
ENVIRONMENTAL NANOSCIENCE

OBJECTIVES:

- To impart knowledge to the students on fundamental of nanoscience.
- To make the student conversant with the synthesis and characterization of nanomaterials.
- To familiarize the student with environmental applications of nanomaterials.

UNIT I
NANOSCIENCE AND NANOTECHNOLOGY


UNIT II
PREPARATION OF NANOMATERIALS

General methods of synthesis of nano particles: Nucleation and particle growth-Sol gel process,chemical precipitation, Hydrothermal synthesis, pyrolysis, vapor deposition; synthesis of metallic, semiconductor and metal oxide nano particles.

UNIT III
CHARACTERIZATION OF NANOMATERIALS

Properties; optical, thermal, magnetic, mechanical and electrical- Characterization of nanomaterials; SEM(EDX),TEM,AFM,XRD,XPS,IR and TGA.

UNIT IV
NANO COMPOSITES

UNIT V VENVIRONMENTAL APPLICATIONS OF NANO MATERIALS

Origin of environmental nanoparticles Nanoparticles in air and water -Health, safety and environmental impacts - Applications of nano materials and nano components in remediation (CNTs, Photocatalysts, Zero valent iron- Gas Sensors-Nanomaterials for hydrogen storage);

TOTAL: 45 PERIODS

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:

- Apply characterization skills to elucidating structure, property relationships, process optimization (for desired properties) and consistent material manufacturing.
- Support fundamental R & D, process development, characterization and consistent/good manufacturing practice.

ES8006 GEO-INFORMATICS FOR ENVIRONMENTAL MONITORING L T P C

OBJECTIVES:
- To educate the students on aspects of Remote Sensing
- Develop the different remote sensing technique
- To educate the students on aspects of GIS and data management
- Develop the GIS Applications for monitoring and management of environment.

UNIT I INTRODUCTION TO REMOTE SENSING

UNIT II REMOTE SENSING TECHNIQUES
Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR

UNIT III SATELLITE REMOTE SENSING AND DATA PROCESSING
Satellites and their sensors , ISRO satellites, LANDSAT, TERRA, SPOT, ERS satellites, Characteristics of Remote Sensing data, Satellite data analysis , Photogrammetry, Visual image interpretation, Digital image processing – Image rectification, enhancement, transformation, Classification, Data merging

UNIT IV GEOGRAPHICAL INFORMATION SYSTEM
Introduction to GIS, GIS concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Database management – Overview of GIS software’s, RS – GIS Integration, Image processing software
UNIT V  REMOTE SENSING AND GIS APPLICATIONS  9
Monitoring and management of environment, Conservation of resources, sustainable land use, Agriculture, Coastal zone management

TOTAL: 45 PERIODS

REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to:
• Identify the environmental problems using Remote sensing.
• Apply the principle of RS and GIS for solving Environmental problems.
• Assess the Environmental Impacts using RS and GIS.
• Employ modern engineering tools in environmental studies.
• Function on a multi-disciplinary team.

ES8007 MARINE RESOURCES AND MANAGEMENT  L T P C 3 0 0 3

OBJECTIVES:
• To educate the Coastal and Marine environment.
• To educate the marine resources
• Students will gain competency in the field of ocean study

UNIT I  MARINE ENVIRONMENT AND COASTAL PROCESS  9
Seas and oceans, Continental area, Coastal zone, Properties of sea water, Coastal eco system, Communities of the marine environment, Marine Bio-diversity, Importance of Coastal Environment – food, transportation, recreation, Coastal hydrodynamics, Interaction between water and coastal sediments

UNIT II  MARINE RESOURCES  10
Food web and energy fluxes, Nutrient enrichment, Biomass, Economic Importance of marine biota – Microbes, Benthos., Algae, Seaweeds Seagrass, Coral reef , Mangroves – importance, interaction of mangroves with other allied and nearby coastal ecosystems – estuaries, lagoons, salt marshes etc.

UNIT III  ENERGY RESOURCES  8

UNIT IV  ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES  9
Human intervention on marine resources, Marine pollution sources and effects, Need for conservation, Resource allocation conflicts, Coastal threats – Indian scenario, Coastal economic concepts, Issues in ecological security of coast - Protecting livelihood of coastal communities, stake holders.
UNIT V  COASTAL ZONE MANAGEMENT 9

TOTAL: 45 PERIODS

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:

- Know about marine environment.
- Have knowledge on physical concepts lying behind the oceanic currents and natural processes of various activities happening over the marine environment.
- Acquire knowledge on the marine pollution and the effect of the same on the ecology.

ES8008  OCCUPATIONAL HEALTH AND INDUSTRIAL SAFETY  L T P C 3 0 0 3

OBJECTIVES:

- To educate about the health hazards and the safety measures to be followed in the industrial environment.
- Describe industrial legislations (Factories Acts, Workmen's Compensation and other laws) enacted for the protection of employees health at work settings
- Describe methods of prevention and control of Occupational Health diseases, accidents/emergencies and other hazards

UNIT I  INTRODUCTION 9
Need for developing Environment, Health and Safety systems in work places - Accident Case Studies - Status and relationship of Acts - Regulations and Codes of Practice - Role of trade union safety representatives. International initiatives - Ergonomics and work place.

UNIT II  OCCUPATIONAL HEALTH AND HYGIENE 11

UNIT III  WORKPLACE SAFETY AND SAFETY SYSTEMS 11

UNIT IV  HAZARDS AND RISK MANAGEMENT 7
UNIT V  ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT  

TOTAL: 45 PERIODS 

REFERENCES: 
1. Fundamentals of Industrial Safety and Health by Dr. K.U. Mistry, Siddharth Prakashan, 2012 
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995 

OUTCOMES: 
After completion of this course, the students is expected to be able to: 
- Describe, with example, the common work-related diseases and accidents in occupational setting. 
- Name essential members of the Occupational Health team. 
- What roles can a community health practitioners play in an Occupational setting to ensure the protection, promotion and maintenance of the health of the employee. 

ES8009  RESTORATION ECOLOGY  

OBJECTIVE: 
The course provides an insight on the principles of restoration of an ecosystem and the techniques and monitoring methods for the restoration. 

UNIT I  INTRODUCTION TO RESTORATION ECOLOGY  

UNIT II  THREATS OF ECOLOGY  
Toxicology and Ecotoxicology- Extinction – Threats of Biological Diversity - Habitat Fragmentation- Pollution- Natural Drivers- Overexploitation- Habitat Conversion- Climate Change- Hybridization. 

UNIT III  RESTORATION APPROACH AND RESTORATION PLANNING  

UNIT IV  RESTORATION OF ECOSYSTEM  

UNIT V  MANAGEMENT OF RESTORATION PROJECTS  

TOTAL: 45 PERIODS
REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to:
- Plan the activities for restoration of a degraded ecosystem with the best available techniques.

ES8010 RURAL WATER SUPPLY AND SANITATION

OBJECTIVE:
- To educate the students on the principles rural water supply and sanitation.
- To develop an understanding of the characteristics of water and wastewater that must be considered during design of a treatment plant.
- To develop understanding of events governing the rural water supply and sanitation.

UNIT I DEVELOPMENT OF WATER SOURCES
Sources of water – Surface and ground water sources – Development of deep bore wells; Estimation of yield – Alternate ways of water supply – Rain water harvesting pumps – Types and selection of pumps for deep bore wells – Construction, inspection and maintenance.

UNIT II WATER TREATMENT

UNIT III SANITATION
Basic requirement of sanitation; Decentralized / onsite wastewater management; small bore / settled effluent sewer.

UNIT IV SEWAGE TREATMENT
Fundamentals of sewage treatment; Decentralized sewage treatment; Septic tank with depression – DEWATS, Intermittent sand filters.

UNIT V SEWAGE DISPOSAL AND REUSE
Methods of disposal, Land disposal, sewage farms – Artificial recharge of ground water; Recycle and Reuse of sewage – Grey water Harvesting – Salt water intrusion and remediation – Ground water pollution and remediation.

TOTAL: 45 PERIODS

REFERENCES:

OUTCOMES:
On completion of the course, the candidate will be able to:
- Identify and formulate problems for rural application.
- Develop conceptual schematics required for the treatment of water and wastewater for rural application.
- Function on a multi-disciplinary team
- Identify pertinent criteria constraining the design of systems and processes.
OBJECTIVE:
- To educate the students to acquire knowledge on different ecosystems and their values and the need for the conservation of ecosystems.

UNIT I  INTRODUCTION  9

UNIT II  ECOLOGY AND ECOSYSTEM SERVICES  9
Ecosystems- Aquatic, Terrestrial – Supporting services– Provisioning services – Regulating Services – Cultural Services
Resources – Ecosystem health – Ecological indicators.

UNIT III  BIODIVERSITY AND BIOLOGICAL CONSERVATION  9
Hot spots- Species loss – Threats – Habitat destruction, genetic pollution, human population, over exploitation, climate change – Global Change

UNIT IV  ECOSYSTEM CONSERVATION  9

UNIT V  ECOSYSTEM SUSTAINABILITY  9
Ecological knowledge - Ecological Sustainability – Importance of Sustainability – Types of sustainability – Recycling sustainability, Green Sustainability - Natural Resource sustainability, living sustainability, Water movement sustainability, Sustainability Agroforestry – Environmental Policy

REFERENCES:

OUTCOME:
On completion of the course, the candidate will be able to,
- Know the importance of ecosystems and the various approaches for the sustainability of the ecosystems.