M.Sc Programme in Environmental Sciences

- **Total No. of seats: 20**

- **Eligibility criterion:**

- B.Sc graduates in the area related to life sciences, chemistry, biochemistry, biotechnology and biophysics

Structure of the
Approved M.Sc. Programme in Environmental Science

Program Objectives

- To orient the students towards the multidisciplinary and interdisciplinary environmental discipline and prepare them for integrated approach to the Environmental Protection and Management.
- To produce graduates strong in Environmental Sciences and capable of venturing into Environmental Technology and Environmental Management fields.
- To produce the environmentalists, who are sensitive to and well aware of the environmental concerns, issues and problems, and able to apply their specialized and modern environmental knowledge for the environmentally sound development.
- To prepare students for successful career in the industry; regulatory agencies, boards and departments; consulting firms; and academic and R&D institutions.

Semester-1

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PMA101	Basic Mathematics	3	1	0	3.5
	PBT101	Introductory Biology				
2.	PEV102	Environmental Chemistry and Toxicology	3	1	2	4.5
3.	PEV103	Ecology, Environment and Sustainability	3	0	2	4.0
4.	PEV104	Atmospheric Sciences, Air Pollution and Meteorology	3	0	2	4.0
5.	PEV105	Earth Systems Science	3	0	0	3.0
6.	PEV106	Environment Policy and Legislation	3	0	0	3.0
		Total	**18**	**1**	**6**	**22.0**

Semester-2

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEV201	Statistical & System Analysis	3	0	2	4.0
2.	PEV202	Energy, Environment and Climate Change	3	1	0	3.5
3.	PEV203	Environment Unit Processes and Operations-I	3	1	2	4.5
4.	PEV204	Management & conservation of Natural Resources	3	0	0	3.0
5.	PEV205	Environmental Biology	3	0	2	4.0
6.	PEV206	Environment Monitoring & Analytical Techniques	3	0	2	4.0
		Total	**18**	**1**	**8**	**23.0**

Semester-3

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEV301	Environment Unit Processes and Operations-II	3	1	2	4.5
2.	PEV302	Environment Impact Assessment & Auditing	3	1	0	3.5

3.	PEV303	Solid Waste Management	3	0	0	3.0
4.		Elective-I	3	0	0	3.0
5.		Elective-II	3	0	0	3.0
6.		Elective-III	3	0	2	4.0
7.	PEV391	Summer Assignment				2.0
		Total	**18**	**2**	**4**	**23.0**

Semester-4

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEV491	Seminar	0	0	0	4.0
2.	PEV492	Dissertation	0	0	0	**12.0**
		Total	0	0	0	**16.0**

Elective 1

S.No.	Course No.	Course Name	L	T	P	Cr
1.	PEV304	Industrial Waste Management	3	0	0	3.0
2.	PEV305	Watershed Management	3	0	0	3.0

Elective II

S.No.	Course No.	Course Name	L	T	P	Cr
1.	PEV306	Agriculture and Environment	3	0	0	3.0
2.	PEV307	Environmental Biotechnology	3	0	0	3.0

Elective III

S.No.	Course No.	Course Name	L	T	P	Cr
1.	PEV308	Environmental Safety and Management	3	0	0	3.0
2.	PEV309	Urban Environment Management	3	0	0	3.0

- **Total Number of Credits: 84.0**

Program Outcomes

- Acquired fundamental knowledge and understanding of the physical environment (land, water, air and climate).
- Developed environmental monitoring skills, including design and conduct of experiments and data analysis.
- Became aware of the local, regional and global environmental problems and acquired the knowledge and skills needed for the environmental management.
- Become aware of the environmental policies, legislation and regulations.
- Obtained exposure to the environmental technologies and to the environmental management, specially, to the waste management.

- Acquired skills in the scientific and technological communications, and in the preparation, planning and implementation of environmental projects, and obtaining firsthand experience of working in the environmental projects.

PMA101 BASIC MATHEMATICS

L	T	P	Cr
3	1	0	3.5

Real Number Systems: Linear and quadratic equations - Permutations and combinations, Bionomial theorm, Complex numbers.
Differentiation: Limit, continuity and differentiability, Differentiation of standard functions, Product rule quotient rule, Applications of derivatives, Cartesian graphing using first and second order derivatives.
Integration: Integration by parts, Substitution and Partial fraction, Properties - Definite integrals and applications to area of regions.
Differential Equations: Solution of differential equations of first order and second order differential equations with constant coefficients.
Determinants and Matrices: Properties of determinants, Elementary operations, Rank of a Matrix, Row reduced echelon form, Solution of system of linear equations, Matrix inversion using row reduction
method.
Coordinate Geometry: Systems of Co-ordinates in two Dimension, distance formula area of triangle, locus, slope of line, various forms of equations of a line, equation of circle (Standard and general form).

Recommended Books

1. *Hall S and Knight SR, Higher Algebra, Laxmi Publications (2000).*
2. *Thomas GB and Finney RL, Calculus and Analytical Geometry, Pearson Education (2007) 9th ed.*
3. *Simmons GF, Differential equations, McGraw Hill (2006).*
4. *Narayan S, Differential and Integral Calculus, S. Chand (2005).*
5. *Krishnamurthy VK, Mainra VP and Arora JL, An Introduction to Linear Algebra. Affiliated East-West Press. (1976).*

PBT101 INTRODUCTORY BIOLOGY

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- Provide a broad perspective of the field of biology
- Introduce the major kinds of organisms
- Introduce aspects related to how these organisms work and interact
- Establish a background for further studies leading to environmental sciences

Introduction: Definition of biology and its various branches, Origin of life, Molecular basis and characteristics of life, Levels of biological Organization.
Diversity of Living World: Microbes, Plant kingdom and its classification, Animal kingdom and brief description of non-chordates and chordate phyla, Typical features of animal life.
Cellular and Structural organization: Prokaryotes and eukaryotes, Basic structure of plant and animal cells, Organization of plant and animal tissues, Plant morphology and anatomy.
Growth and Development: Basics of cellular division, Processes of mitosis and meiosis, Mendel's Laws of inheritance, Patterns of inheritance – Incomplete dominance, Multiple alleles, Co-dominance, Lethal genes, Polygenic inheritance, Sex linked inheritance.
Plant Physiology: Plant Growth, Transportation of fluids, Mineral nutrition, Photosynthesis in higher plants, Plant growth, Respiration, Plant growth harmones, Reproduction in Plants.
Animal and Human Physiology: Digestion and absorption, Breathing and exchange of gases, Body fluids and circulation, Excretion, Neural control and coordination, Chemical coordination and integration, Animal reproduction.

Course Outcomes:

- Able to define the fundamentals entities of the biological world and how they work
- Promote an appreciation of humans as a part of the world's ecosystems and the relevance of biological science to contemporary concerns;
- Develop working knowledge of the processes of evolution that explain why many organisms share specific similarities and also display great diverstiy of organization, structure, function, and behaviour.

Recommended Books

1. *Bhatia KN and Tyagi MP, Elementary Biology, Trueman Book Company (2005)*
2. *Dhami PS, Srivastava HN and Chopra G, A Textbook of Biology, Pradeep Publications (2007)*
3. *Campbell NA and Reece JB, Biology, Pearson-Education Inc. (2005)*
4. *Lehninger AL, Nelson DL and Cox MM, Lehninger Principles of Biochemistry, Macmillan Learning (2016)*

PEV102 ENVIRONMENTAL CHEMISTRY AND TOXICOLOGY

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- Facilitate understanding of the biological effects of chemicals in the environment on organisms, including humans.
- Develop insights into key concepts in the field of environmental toxicology
- To think critically on environmental quality and risk assessment issues

Environmental Chemistry

Principles: Stoichiometry; pH, acidity, alkalinity and hardness; Acids, bases and buffers; Solutions; Oxidation-reduction reactions, Equilibrium chemistry; Colloidal chemistry; Electrochemistry; Catalysis; Ion exchange; Adsorption, Chemical and photo-chemical reactions of the troposphere; stratospheric ozone chemistry; Atmospheric aerosol chemistry; Chemistry of greenhouse gases, Chemical, thermal and catalytic reactions and their kinetics; Fuel combustion processes; Order of reactions and reaction rates.

Chemistry of water: Water as a solvent, physical properties of water, molecular structure and intermolecular forces, comparison of water with behavior of other small molecules, formation of aqueous solutions, molarity and other measures of concentration, water in biology, surface tension, anomalous properties of water.

Basics of Thermodynamics: Energy interconversion, The First Law, Enthalpy, heat capacities, expansions. Thermochemistry. Bond energies, Energy cycle applications. Spontaneous processes, entropy, The Second Law, Entropy changes, The Third Law, Standard entropies. Gibbs and Helmholtz functions, Chemical potential. Criteria of spontaneous changes and equilibrium, Chemical equilibrium and the determination of equilibrium constants.

Chemical Constitution of environmental components: Chemical constituents and chemical characterization of water, air, soils and other substances.

Environmental Toxicants: Heavy metals, Hydrocarbons, PAH, PCBs, Phenols, Chlorofluorocarbons, Pesticides and Chemical fertilizers.

Green chemistry: Principles of green chemistry and cleaner production technologies.

Eco-toxicology

Principles: Toxicology and eco-toxicology; Types of toxic substances; Influence of ecological factors on the effects of toxicity; Sigmoid relationships, Corollary of toxicology

Ecotoxicity: Toxic substances in the environment and their sources and entry roots; Transport of toxicants through air and water and through food chains; Ecosystem influence on the fate and transport of toxicants; Bio-transformation and bio-magnification.

Toxicity and Dose-Response: Entry routes of toxicants into human body; Response to toxin exposures (Lethal and sub-lethal doses, Dose- Response relationships); Analysis of NOEL, LD_{50}, LC_{50} and MLD; Detoxification of human body (mechanisms and organs of detoxification).

Laboratory Work: Analysis of environmental samples by Gravimetry, Titrimetry, DO meter, Conductimeter, Turbidity meter, Spectrophotometer, Flame photometer, AAS, pH/ISE meter, GC, and Orset apparatus for various parameters; Toxicity testing: LC_{50}, LD_{50} and whole effluent toxicity.

Course Outcomes:

- Develop sound theoretical background of basic chemistry associated with toxicology of environmental pollutants
- Able to apply principles of toxicology in analyzing the threats associated with chemical in environment
- Apply basic analytical tools to determine and measure toxicants in various environmental samples

Recommended Books

1. *Sawyer CN, McCarty PL and Parkin GF, Chemistry for Environmental Engineering and Science, McGraw Hill (2003)*
2. *Manahan SE, Fundamentals of Environmental Chemistry, CRC Press LLC (2008) 3rd ed.*
3. *Shaw IC and Chadwick J, Principles of Environmental Toxicology, Taylor& Francis ltd. (1998)*
4. *Manahan S, Environmental Chemistry, CRC Press (2017)*
5. *Cengel Y and Boles M, Thermodynamics- An Engineering Approach, McGraw-Hill (2017)*
6. *Nag PK, Engineering Thermodynamics, McGraw Hill Education (2017)*

PEV103 ECOLOGY, ENVIRONMENT AND SUSTAINABILITY

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- Describe and define the structural and functional attributes of ecosystems
- Define the concept of sustainability in different contexts
- Understand the major environmental, social and economic drivers of sustainability challenges

Ecology and ecosystems: Ecosystem and components of ecosystem; Structure, function and dynamics of ecosystem; Cybernetics of ecosystems.

Ecosystem dynamics and Energy flow : Solar energy; Entropy and enthalpy, and non-equilibrium thermodynamic systems; Energy quality; Trophic levels, food chains and food webs; Trophic structure and ecological pyramids; Energy flow through ecosystems; Ecosystem productivity, Primary and secondary succession, and expected trends during succession; Concept of climax; Influence of disturbances on ecosystems; Biosphere and its evolution.

Material cycling: Biogeochemical cycles (sedimentary and gaseous cycles); Nutrients and nutrient cycling in ecosystems; open-ness and fragility of ecosystems; Bio-magnification and food chain contamination.

Population and community ecology: Populations and communities; Population growth patterns; Biological factors and physical environment, and population control; Population structure, life tables and age structure; Biodiversity, and diversity and dominance indices.

Biosphere: Origin and evolution of life on the planet earth and evolution of the atmosphere; Biodiversity; Biomes and major natural ecosystem types of the planet earth: desert, ocean, wetland, freshwater

Sustainability: Sustainable development and its dimensions; The Millennium Development Goals; Agenda-21; The Earth Charter; Strategies for implementing sustainable development; Orienting agricultural and industrial systems towards sustainability; Management of natural resources for sustainability; Human consumption and sustainability.

Laboratory Work: Algal chlorophyll estimation and relating with photosynthesis and respiration rates; Oxygenation potential of aquatic macrophytes and algae of water bodies; Life tables and survivorship curves; Dominance and diversity indices; Vegetation analysis; species distribution in microcosms; isolation and basic characterization of bacteria in water.

Course Outcomes:

- Able to analyze the goals, indicators, benefits and limitations of sustainability
- Develop competence to formulate short and long term sustainability objectives and plans
- Able to appraise and evaluate sustainability practices for maintenance of ecologically sound development

Recommended books

1. *Odum EP, Basic Ecology, Holt-Saunders International Editions (1983)*
2. *Kormondy EJ, Concepts of Ecology, Prentice Hall (1999)*
3. *Benton AH and Werner WE, Field Biology and Ecology, McGraw Hill (1974)*
4. *Sharma PD, Ecology and Environment, Rastogi Publications (2016)*

PEV104 ATMOSPHERIC SCIENCES, AIR POLLUTION AND METEOROLOGY

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- To acquire fundamental knowledge and understanding of atmospheric sciences
- Becoming aware of the local, regional and global air pollution related issues.
- To understand the effect of climatic conditions on the dispersion of air pollutants.

Atmosphere Phenomena: Atmosphere and its functions, structure and composition of atmosphere; Reactions in the lower and upper atmosphere. Different layers, their characteristics and temperature relationships, Gas laws governing the behaviour of pollutants in atmosphere, natural and anthropogenic sources of atmospheric pollutants, Precipitation and types of storms, Influence of solar radiations on earth atmosphere. Diffuse solar radiations - controlling factors, Distribution of sunshine hours, Weather forecasting and methods involved.

Meteorology: Fundamental parameters – Pressure, temperature, wind, humidity, radiation, atmospheric stability, turbulence and diffusion. Wind roses, atmospheric stability, inversions, mixing height and topographic effects. Application of meteorological principles to transport and diffusion of pollutants, Scavenging processes. Gaussian plume model for the calculation of ground level concentration, Pasquilli's stability classification, plume behaviour, plume rise and calculation of effective stack height.

Air Pollution: Sources, types and fate of pollutants, persistent organic and inorganic air pollutants, Priority air pollutants, Air quality standards, Effects of air pollutants on plants, animals and property.

Sampling and Monitoring Air Matrices : Scope, Purpose and Objectives of Air Quality Monitoring Program; Preliminary information required for planning an air quality survey; Guidelines for planning a survey; Design of an air quality surveillance network; Period, frequency and duration of sampling; Averaging times; Sample size determination. Principles and instruments for measurement of – (i) ambient air pollutants; and (ii) stack emissions

Air quality management plans and programs: Overview of current air quality trends and challenges, Air Quality Index, Regulatory mechanism, clean air action plan for cities, Fiscal incentives, Control of industrial Pollution, Control of Mobile Source Emissions, Indoor air pollution: Sources, origin, types, their effects and remedial measures.

Laboratory Work: Dustfall/Total Suspended Particulates, Respirable dust Sampling, Flow rate measurements, High volume and handy samplers (collection of gaseous and particulate samples). SO_2, NO_X, analysis by wet chemistry method. Flue gas Analysis, Measurement of meteorological parameters by weather monitoring station, Plotting wind roses.

Course Outcomes:

- Understanding of the basic phenomenon's of atmospheric sciences.
- Get acquainted with the sources, properties and ill-effects of important air pollutants in ambient air
- Application of the effect of meteorological parameters in the dispersion of air pollutants.

Recommended Books

1. *Valdia KS, Environmental Geology, Tata-McGraw Hill (1987)*

2. *Boubel RW, Fox DL, Turner DB and Stern AC, Fundamental of Air Pollution, Academic Press (1994)*
3. *Perkins HC, Air Pollution, McGraw-Hill (2004)*
4. *Rao CS, Environmental Pollution Control Engineering, New Age International (2006)*
5. *Rao MN and Rao HVN, Air Pollution, Tata McGraw-Hill (2006)*
6. *De Nevers N, Air Pollution Control and Engineering, Mc Graw Hill (1993)*

PEV105 EARTH SYSTEMS SCIENCE

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- To acquire fundamental knowledge and understanding of atmosphere, hydrosphere and lithosphere
- Becoming aware of the interrelationships between biosphere and environmental components
- To know basic concepts related to hydrogeology

Science of earth – Fundamental aspects: Origin of the Earth; Earth as a complex system of interacting physical, chemical and biological processes and human interactions; Factors and processes that make the earth the only planet sustaining life; geochemical and biogeochemical cycles; The changing earth system and consequences for life on earth. Climates of India, Indian mansoon, El Nino and western disturbances. Natural hazards: Floods, landslides, avalanches, cyclones, droughts.

Earth processes and Environment: Earth processes, concept of residence time and rates of natural cycles, Catastrophic geological hazards: study of floods, landslides, earthquakes, volcanism and avalanche. Prediction and perception of hazards.

Environmental geochemistry: Internal structure and composition of the earth; concept of major, trace and rare earth elements; Types, composition and physical properties of important minerals and rocks; Volcanism and its impacts on the earth's climate; Soil**:** Soil structure and texture; Soil components, soil water and interactions among components; Soil microbial community; Soil fertility and nutrients

Land use planning: The land use plan, soil surveys in relation to use, site selection and evaluation

Hydrogeology: Ground water; Hydrological characteristics of aquifers; Hydrological classification of water bearing formations; Ground water pollution.

GIS and remote sensing: Remote Sensing: Principles, Types and System, Elements of visual image interpretation; visual and digital image processing (DEM), Basic concepts of aerial photography and photogrammetry, Basic components and tools of GIS, Digital Elevation Model (DEM) and its application; basic principle of Global Positioning System (GPS), Role of Remote Sensing and GIS in Environmental Management

Laboratory Work: Rocks and minerals; GPS for survey; basics of GIS, soil structure and texture; Organic carbon and biotic community of soils.

Course Outcomes:

- Aware of the basic phenomenon's of earth sciences
- Get acquainted with the solar system and exosphere
- Understood the concepts of hydrogeology.

Recommended books

1. *Keller EA, Introduction to Environmental Geology, Prentice Hall (2008)*
2. *Noel C, Demeritt D, Liverman D and Rhoads B, A Companion to Environmental Geography, Blackwell (2009)*
3. *Skinner BJ, Porter SC and Botkin BD, The Blue Planet: An Introduction to Earth System Science, John Wiley & sons (1999) 2nd ed.*

PEV106 ENVIRONMENT POLICY AND LEGISLATION

L	T	P	Cr
3	0	0	3.0

Course Objectives:

- To have overview on environmental policies and legislations
- To understand the role of pollution control boards and their procedures
- To have insight into major acts and rules applicable for environmental pollution control

Definitions of Terms: Conventions, protocols, policy, law, act and rule, administrative and legal interpretations, codes and specifications.

Overview: Constitutional provisions and overview of the Indian environmental law; Overview of the Indian environmental legislation; Overview of environmental policies of the Govt. of India.

Key Environmental Acts: The Water (Prevention and Control of Pollution) Act, 1974; The water (prevention and control of pollution) cess act, 1977; The air (prevention and control of pollution) Act, 1981; The Environment (Protection) Act, 1986; Public Liability Insurance Act, 1992; National Environmental Appellate Authority Act, 1995 and National Environmental Tribunal Act, 1997, Forest (Conservation) Act, 1980; Wild Life Protection Act, 1972, and Biodiversity Act 2002, The National Green Tribunal Act, 2010.

Procedures: Environmental clearances; Consents and authorizations under the Water Act, Air Act and Environmental Protection Act; Environmental Sampling and Environmental Standards;

Key Environmental Regulations**:** Solid Waste Management Rules, 2016, Biomedical Waste Management Rules, 2016; The Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016 ,Chemical accident rules,1996, Ozone depleting substances rules, 2000, Batteries rules, 2000, Noise pollution rules,2000 and Plastic waste rules, 2016, Flyash Notification 2016. The Construction and Demolition Waste Management Rules, 2016.

International Protocols and Conventions: Montreal Protocol, Biodiversity Convention, Framework convention on climate change, Vienna convention, Ramsar convention, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes, Convention to combat desertification.

Course Outcomes:

- Becoming aware of the environmental legislation, environmental policies of the country and of the international environmental conventions and protocols.
- Knowing the environmental regulations applicable to the industry and other organizations with significant environmental aspects
- Application of the legislation concepts for solving the local environmental problems.

Recommended books/weblinks

1. *http://moef.nic.in/modules/rules-and-regulations*
2. *http://moef.nic.in/treaties/international-treaties.html*
3. *Pollution Control Acts, Rules and Notifications Issued Thereunder: Pollution Control Law Series, Central Pollution Control Board, New Delhi (2006)*
4. *Environment law by PS Jaswal, Allahabad Law agency (2016)*

5. *Jaswal PS, Environmental Law, Allahabad Law Agency (2016)*

PEV201 STATISTICAL AND SYSTEM ANALYSIS

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- To make aware of the statistical tools and techniques available for the environmental data analysis and inferring
- To introduce the statistical modeling and parameter optimization studies.
- To provide basic understanding of Environmental Systems and Analysis and exposure to some of the commonly used ecological and environmental (pollution) models.

Variables, Probability and Distributions: Random variables; Expectation, variance and moments (Arithmetic, geometric and harmonic means and standard deviation), Probability and probability distributions, Normal, binomial, poisson, geometric, hypergeometric, log normal, gamma and weilbull distributions.

Curve Fitting: Populations, sampling, measurement and distribution of attributes, Method of least squares, Curve fitting, Regression analysis, Testing of goodness of fit (t test and X^2 test, etc.).

Statistical Testing: Matrices and simultaneous linear equations, Test of hypothesis and significance, Analysis of variance, Selected non-parametric tests.

Multiple Regression Analysis: Principal component analysis, Factor analysis, Cluster analysis, Design of experiments and response surface methodology, Linear simple and multiple regression models, Validation of models and forecasting with models.

Basics of Environmental System Analysis: Survivorship curves and life tables, Approaches to development of models, Point source stream pollution model; Box model, Gaussian plume model.

Laboratory Work: Survivorship curves and life tables; Working on SPSS software; Design of experiments; Statistical modeling by response surface methology.

Course Outcomes:

- Being aware of the statistical tools and techniques and has the capability to analysis the environmental data and infer.
- Obtain knowledge of probability and distributions and become capable of mathematical expectations.
- Acquire the skills of regression and correlation analysis, and development of statistical models and their use.
- Become capable of design of experiments for research studies and testing of the related hypotheses.
- Have understanding of the environmental systems and their analysis and become acquainted with the widely used ecological and environmental models.

Recommended Books

1. *Johnson RA, Probability and Statistics for Engineers, Prentice Hall (2004)*
2. *Box, GEP and Hunter WG, Statistics for Engineers and Scientists, John Wiley (1987)*
3. *Meyer PL, Introductory Probability and Statistical Applications, Addition Wesley (1972)*

PEV202 ENERGY, ENVIRONMENT AND CLIMATE CHANGE

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- To understand the interrelationship of energy and environment.
- To know the impacts of energy systems on environment.
- To know the basic concepts of climate change and strategies for conservation of environmental changes.

Energy and Environment: Sun as source of energy, nature of its radiation, heat budget of the earth, Energy resources and their exploitation. Conventional and non-conventional energy sources: Fossil fuels-coal, oil and nature gas: environmental impacts of conventional energy resources, need of non conventional energy resources such as Hydroelectric power; Geothermal energy; Oceanic energy; Wind energy- wind energy conversion systems, criteria for site selection; Biomass energy- biomass energy conversion technologies (wet and dry processes), types of gasifiers, biogas generation; Tidal Energy; Solar Energy- solar collectors, photovoltaic's, solar ponds, solar water heating systems; Nuclear energy -fission and fusion; Environmental implication of energy use, CO_2 emission in atmosphere. Fall out from nuclear explosions – fuel processing and radioactive waste

Innovative Energy Technologies for the Future: Limitations of traditional energy technologies, criteria for the selection of new energy sources, alternative liquid fuels (Alcohol fuel), magneto hydro dynamic (MHD) power generation, fuel cells, hydrogen as on alternative fuel, its production, conversion and use as energy sources. Future prospects for innovative energy technologies and their environmental concerns

Global Climate Change: Elements of climate, Climatic classifications, climatic controls, Spatial and temporal patterns of climate parameters in India. Indian monsoon jet streams, general circulation and urban climatology. Causes and consequences of Global Warming, Ozone hole and consequence of Ozone Depletion, Montreal Protocol, Kyoto protocol and recent conventions. Climatic considerations in Industrial locations, city planning, landscape architecture and abatement/mitigation of pollution, Strategies for Conservation of Environmental Changes induced by CO_2 Rise, the concept of Carbon Sequestration. Clean Development Mechanism (CDM) and its operationalization, modalities and procedures for CDM Project. Automobile Emission Characteristics, Indian Scenario, Impact of Automobile Pollutants and its Abatement.

Course Outcomes:

- Acquiring scientific and technological understanding on the energy and associated environmental issues
- Get acquainted with the environmental impacts of energy technologies
- Knowing the issues related to climate change, related protocols and modalities as well as procedures for CDM projects

Recommended books

1. *Maheswar D, Renewable Energy Environment and Development, Konark Publishers (1998)*
2. *Tiwari GN, Renewable Energy Resources: Basic Principles And Applications, Narosa Publishing House (2005)*
3. *Rai GD, Conventional and Non-conventional Energy sources, Khanna Publishers (2000)*

4. *Cassedy ES, Prospect of Sustainable energy: A critical Assessment, Cambridge University Press (2000)*

PEV203 ENVIRONMENTAL UNIT PROCESSES AND OPERATIONS-I

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- To understand the science and technology of water and wastewater treatment
- To know design, analysis, operation and control of common water and wastewater treatment units.
- To understand the water quality guidelines, criteria and standards.
- To bring out the need for advanced techniques for treating water and wastewater.

Characterization of water and wastewater: suspended, colloidal and dissolved solids (TSS, TDS, volatile and fixed solids); biological water quality; pH, acidity, alkalinity and hardness; sulfates, chlorides, cyanides and fluorides; heavy metals; and pesticides.
Sedimentation/settling: Stokes law; types of settling; grit chambers; primary settling; tube settlers; and secondary settling.
Coagulation-flocculation: properties and sources of colloids; coagulants and coagulant aids; optimum dose of coagulants ; flash mixing, flocculation and settling; and basics of electrocoagulation-electroflocculation.
Neutralization and precipitation: titration curves and buffering; defloridation; precipitation removal of metals; and precipitation removal of phosphorus.
Filtration: surface filters and depth filters; Slow sand filters and rapid gravity filters (and pressure filters); filter media and their properties; gravel bed support and underdrain systems; filter back washing and head loss across filters; basics of ultra-filtration and nano-filtration.; Reverse Osmosis; Electrodialysis.
Disinfection: Biological water quality; Chlorination systems, break point chlorination and residual chlorine; kinetics of chlorination, Ozonation; UV radiation treatment.
Adsorption and Ion-exchange processes: Adsorption isotherms; powdered activated carbon adsorption; granular activated carbon adsorption; regeneration of adsorbents. Chemistry of Ion exchange resins
Introduction to Advance-oxidation processes
Aeration, mixing and stripping: Basics of mixing and aeration; Power requirements; Mixers; Floating and surface aerators
Laboratory Work: Alkalinity/acidity, titration curves and buffer intensities; Settling column tests for primary and secondary clarifiers; Optimum coagulant dose for coagulation, Break point chlorination; Adsorption and adsorption isotherms; Ion-exchange capacity.

Course Outcomes:

- Acquiring scientific and technological understanding on the physico-chemical operations and processes used in the treatment of water and wastewater.
- Knowing how to design, analyze, operate and control the routinely used physico-chemical water and wastewater treatment units.
- Understanding the water/wastewater characterization and the treatment units' monitoring required for their design, operation and control, and acquiring the related monitoring and analytical skills.
- Acquiring the skills for performance evaluation of water/wastewater treatment plants

Recommended books

1. *Tchobanoglous G and Burton FL, Metcalf & Eddy Wastewater Engineering: Treatment and Reuse, Tata McGraw Hill (2003)*
2. *Davis ML, Water and Wastewater Engineering: Design Principles and Practices, McGraw Hill (2011)*
3. *Sawyer CN, McCarty PL and Parkin GF, Chemistry for Environmental Engineering and Science, McGraw Hill (2003)*
4. *Weber WJ, John Wiley,Physico-chemical Processes for Water Quality Control(1986)*

PEV204 NATURAL RESOURCES MANAGEMENT AND CONSERVATION

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- Encourage the integration of environmental issues and themes into courses and student projects in the basic and natural sciences
- Foster an understanding of fundamental environmental issues, including biological diversity and the preservation of natural ecosystem integrity, both in the University community and the public at large

Natural resources and their classification: Potential, actual, reserve and stock resources; Biotic and abiotic; Renewable and non-renewable; Flow and fund resources; Biological (fisheries, wildlife, forests, biodiversity), land, water, energy and mineral resources.

Use of natural resources: Extraction (harvesting, mining, fishing), transportation, storage, processing and use of resources; Natural ecosystems and agricultural systems (and industrial systems) in the generation and processing of resources; Human population and consumerism challenges; Resource depletion, environmental degradation, extinction, over exploitation, habitat destruction and/or fragmentation, etc., problems associated with natural resources.

Natural resources and sustainability: Concept of carrying capacity; Resource conservation through proper allocation and efficient use; Viewing natural resources as capital, and resource conservation through resource substitution and resource complementing; Technological and human resources in the extraction, processing and use of natural resources; Resource recycling. Management of mineral, energy, water, land and biological resources for sustainability; Management of wastes as resources.

Soil and Water conservation: Need for conservation, erosion by water: types, processes, rainfall and runoff erosivity, soil erodibility, water erosion in crop lands; erosion by wind: processes and factors, erosion of croplands, tillage, grazing systems and degradation of graze lands, erosion in forest systems; rainwater harvesting; modern irrigation systems.

Natural resource management: Key philosophies and concepts; Resource economics; Natural resource audits; Management approaches and history of management approaches; Top-down and bottom-up approaches for management; Scientific method and adaptive management; Decentralized governance of natural resources; Community based natural resource management; Precautionary approach and Integrated approach for natural resource management.

Course Outcomes:

- Students can apply principles of chemical, biological, and physical systems to address natural resource and environmental issues
- Able to effectively communicate natural resource and environmental issues in written, oral, and visual formats to professionals and community stakeholders
- Demonstrate the ability to draw conclusions and make recommendations based on an interdisciplinary understanding of natural and human systems

Recommended books

5. *Brebbia CA, Conti ME and Tiezzi E (eds.), Management of Natural Resources, Sustainable Development and Ecological Hazards, WIT press (2007)*
6. *Richard LK and Courtney W, Conservation for a New Generation: Redefining Natural Resources Management, Wiley Online (2008)*
7. *Richard LK, Sarah FB, Robert C and Steward P, A New Century for Natural Resources Management, Prentice Hall (1995)*

PEV205 ENVIRONMENTAL BIOLOGY

L	T	P	Cr
3	0	2	4.0

Course Objectives

- To define classification of biological systems involved in environmental activities
- To facilitate understanding of the biology of water and wastewater, air and soils
- To describe the role of microbial systems in cycling of nutrients and making environmental activity sustainable
- To be able to define the role of microbial systems in biodegradation and transformation of environmental pollutants.

Nutrition, Energitics and Growth: Nutrition; Environmental conditions; Michelis-Menton and Monad's equations; Enzymes, and enzyme kinetics; Microbial growth and growth kinetics.

Water Biology: Water organisms (microorganisms, plants and animals); Organisms of polluted water; Water organisms as sources of human health hazards and biological water quality; DO depletion and Eutropication problems of water; Roles of water organisms in waste assimilation and treatment.

Soil Biology: Biotic community of soils and rhizospheres; Soil organisms in decomposition, bioremediation and mineralization of wastes; Associations of soil organisms with plants; Role of soil organisms in the soil formation, fertilization, and soil structure and texture maintenance.

Aerobiology: Biological aerosols; Survival and spread of bioaerosols; Bioaerosols as sources of human health hazards.

Biodiversity and bioprospecting: biodiversity of economically important biota, biopiracy, bioprospecting; plant secondary metabolites; natural products; drugs from natural sources, biopharming

Waste Treatment Biology: Aerobic and anaerobic biological wastewater treatment; Biological phosphorus and nitrogen removal; Oxidation ponds and algal ponds for wastewater treatment; Waste stabilization ponds; Vegetated ponds and constructed wetlands; Aerobic and anaerobic sludge digestion; Composting and vermicomposting; mushroom culturing; Biodegradation of priority pollutants (pesticides, petroleum, etc.) and bioremediation.

Laboratory Work: Staining and microscopic examination of microorganisms; Culturing and microbial enumeration by dilution plate, multiple tube fermentation and membrane filtration techniques; Isolation purification and culturing of microorganisms from environmental samples; microbial growth kinetics.

Course Outcomes

- Gain knowledge on the biological environment and its role in ecological functions
- Able to assess the nature of different types of biological systems involved in treatment processes
- Have and understanding of role of biological systems in environmental sustainability

Recommended books

1. *Gaudy AF and Gaudy ET, Microbiology for Environmental Scientists and Engineers, McGraw Hill (1980)*
2. *Pelczar MJ, ChanECS and Krieg NR, Microbiology, McGraw Hill (1996)*
3. *Kolwzan B, Adamiak W, Grabas K and Pawelezyk K, Introduction to Environmental Microbiology: Oficyna Wydawnicza Politechniki Wroclaweskiej, Wroclaw (2003)*
4. *Gray NF, Biology of Wastewater Treatment, Imperial College Press (2004)*

PEV206 ENVIRONMENTAL MONITORING AND ANALYTICAL TECHNIQUES

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- To provide exposure towards environmental monitoring programs and protocols
- To acquire basic skills of sampling with regard to water, wastewater and exhaust gases
- To facilitate learning of various analytical techniques used in environmental monitoring

Conceptual Basis of Environmental Monitoring Systems: Basic concepts, applications and importance of Environmental Monitoring; environmental monitoring programs and protocols; Environmental laboratories; Standards procedures for the sampling and analytical techniques; Instrumentation, equipment and facilities for environmental sampling and analysis; Reference materials; Representative samples; Precision and accuracy; Measurement of uncertainty; Environmental monitoring data analysis and management.

Sampling Techniques: Sampling of waters and wastewaters; Flow measurement and composite sampling; Ambient air quality monitoring; Stack monitoring; Tail pipe emissions monitoring; Noise monitoring; On-line monitoring; Preservation, storage and transportation of environmental samples.

Analytical Techniques: Gravimetry, titrimetry, potentiometry (including ion analyzers), turbidimetry, conductimetry, and colorimetry (UV-visible spectrometry); preparation (digestion, extraction, etc.) environmental samples for analysis; Flame photometry, AAS and ICP; Chromatography, GC, HPLC and IC; PM_{10}, $PM_{2.5}$, high volume samplers, orsat apparaturs and flue gas analysers.

Laboratory Work: Flow measurement and composite sample collection; Ambient air sampling; Stack monitoring; Tail pipe emissions monitoring; Weather monitoring and data analysis; Analysis of samples by gravimetry, titrimetry, potentiometry (including ion analyzers), turbidimetry, conductimetry, and colorimetry (UV-visible spectrometry); Preparation and analysis of samples on flame photometer, AAS and GC; Noise monitoring.

Course Outcomes:

- Having knowledge about monitoring guidelines and environment monitoring programs.
- Trained in the environmental monitoring. techniques.
- Learning of the techniques employed in the environmental analysis.

Recommended Books

1. *Shukla SK and Srivastava PR, Methodology for Environmental Montoring and Assessment, IK Publishers (1992)*
2. *Wiersma G, Environmental Monitoring, CRC Press (2004)*
3. *Patnaik P, Handbook of Environmental Analysis, CRC Press (1997)*
4. *Standard Methods for Examination of Water and Wastewater: APHA-AWWA-WEF; Boston (1989)*
5. *Skoog DA, Holler FL and Nieman TA, Principles of Instrumental Analysis, Harcourt College Publishers (1997)*

PEV301 ENVIRONMENTAL UNIT PROCESSES AND OPERATIONS-II

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- To understand the science and technologies of wastewater treatment processes and operations
- To know the design, analysis, operation and control of the commonly used wastewater treatment units
- To understand the sampling and analytical techniques required for the wastewater characterization and for the monitoring of the wastewater treatment plants.
- To acquire knowledge on the facilities and provisions required for the handling and management of the wastewater treatment plant' sludges and liquid effluents.

Watertreatment operations: Preliminary and primary unit operations.

Biodegradable Organic Matter and Biological Treatment Processes: BOD and BOD kinetics; Aerobic, anaerobic and fermentative bio-oxidation processes; Principles and kinetics of biological treatment; Conditions of biological treatment and nutrients.

Aerobic Treatment Processes: Activated sludge processes and their modifications; Aerated lagoons; Sequencing batch reactors; Trickling filters; Rotating biological contactors; Submerged aerobic filters; Moving bed bioreactors; Membrane bioreactors.

Anaerobic Treatment Processes: UASB reactors, UASB ponds and their modifications; Anaerobic filters; Expanded and fluidized bed anaerobic reactors; Multistage rectors and hybrid reactors.

Biological Nutrient Removal: Biological nitrification and de-nitrification; Biological phosphorus removal.

Other Biological Treatment Processes: Surface re-aeration and algal photosynthesis; Waste stabilization pond systems; Algal ponds and oxidation ditches; Vegetated ponds and Constructed wetland systems.

Sludge management: Biological (anaerobic and aerobic) sludge stabilization; Waste treatment by land application; Composting of bio-solids; Chemical stabilization; Thermal stabilization; encapsulation; solidification. *Sludge Thickening, Dewatering and Drying using* Centrifugal separation; flotation; filter presses; belt presses; screw presses, sludge thickeners; sludge drying beds, etc.

Common effluent treatment plant (CETP) approach for wastewater.

Laboratory work: MLSS, MLVSS, biodegradable VSS and SVI; DO, BOD and COD; BOD kinetics parameters; ASP kinetics parameters; Biogas generation potential of the waste; Total, organic, ammonical, nitrate and nitrite nitrogens; Sulfate, chloride, sulfide and phenols.

Course Outcomes:

- Acquire scientific and technological understanding on biological wastewater treatment processes

- Knowing how to design, analysis, operate and control the routinely used biological wastewater treatment units
- Understanding the wastewater characterization and the biological treatment units monitoring required for their design, operation and control, and acquiring the related monitoring and analysis skills.
- Understanding the facilities and provisions required for the handling and management of the wastewater treatment plant' sludges and treated effluents.
- Calculating the techno-economics for treatment plants.

Recommended books

1. *Wang LK, Pereira NC, Hang YT and Shammas NK, Biological Treatment Processes (Handbook of Environmental Engineering - Series) volume-8, Humana Press (2009)*
2. *Tchobanoglous G and Burton FL, Metcalf & Eddy Wastewater Engineering: Treatment and Reuse,Tata McGraw Hill (2003)*
3. *Davis ML, Water and Wastewater Engineering: Design Principles and Practices, McGraw Hill (2011)*

PEV302 ENVIRONMENT IMPACT ASSESSMENT AND AUDITING

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- Facilitate understanding of the EIA process.
- Inculcate capabilities to interpret environmental management plans and EIA documents.
- Provide understanding of the need and procedures for Environmental auditing
- Provide regulatory guidelines and specifications available for impact assessment and auditing

Introduction, Background and Basics: Environmental clearances, basic steps involved in the appraisal of development projects, and role of EIA; Public participation; EIA and EMP; MoEF guidelines and applicable legal requirements; Terms of reference; Draft and final EIA; Rapid EIA and comprehensive EIA; and Corporate Social Responsibility (CSR).

Impact Analysis: Activities, environmental aspects and environmental impacts; Baseline studies and environmental monitoring and environmental data collection; Identify, predict and evaluate different types of impacts; Tools and methods of impact analysis: checklists, matrices, networks, overlays and GIS, models and expert systems and professional judgements.

Components of Impact Analysis: Socioeconomic impact analysis; Air and water quality impact analysis; Vegetation and wild life impact analysis; Noise impact analysis; Energy impact analysis.

EIA Document: Purpose of preparing and submitting EIA documents, Summary EIA document, Draft EIA and final EIA document, Structure and contents of the EIA document; Environmental management plan and mitigation measures for anticipated environmental impacts.

Environmental Auditing and Life Cycle analysis: Types of audits: EMS audits, performance audits, compliance audits; ISO 19011and environmental auditing; Methodologies for Environmental Auditing: Objectives, audit teams, planning audits, conducting audits, reporting audit findings; Legal Requirements relating to Environmental auditing, Life cycle analysis; ISO 14000 Environmental Management systems.

EIA Case Studies: Mining projects, Highway projects, River valley projects, Thermal power plants, Oil refineries and petrochemicals.

Course Outcomes:

- Acquiring basic skills to take up environmental auditing and lifecycle analysis at specific industries
- Knowing about the environmental requirements applicable to the environmental impact assessment, and about the environmental clearance process of developmental projects.
- Understanding the methods and tools of identification, prediction and evaluation of environmental impacts of developmental projects.

Recommended Books/weblinks

1. *Sadler B and McCabe M, Environmental Impact Assessment: Training Resource Manual, UNEP (2002)*
2. *EIA manual. Ministry of Environment and Forests, Government of India*

(http://www.envfor.nic.in/legis/eia/so195.pdf).
3. *EIA notification, Gazette Notification: SO 1533 dated 14-09-2006, MOEF. GOI (2006)*
4. *Munn RE, Environmental Impact Assessment - Principles and Procedures, Scientific Committee on Problems of the Environment (SCOPE)-5 (1979)*
5. *Petts J, Handbook of Environmental Environmental Impact Assessment, Taylor & Francis (1995)*
6. *ISO 19011: 2011: Guidelines for auditing management systems.*

PEV303 SOLID WASTE MANAGEMENT

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- Understanding, types, properties of solid waste and its pollution potential.
- Detailing on feasible treatment technologies for resource recovery and recycling from solid waste.
- A focus on special categories of solid waste.
- Concept application for meeting the challenges of solid wastes in urban centres.

Solid and Hazardous Wastes: Definition, sources and characteristics; Sampling and analysis techniques; Inventorying wastes; Strategies for waste minimization.

Municipal Solid Waste Management: Segregation and recycling and reuse of wastes; Collection, transportation and storage of municipal solid waste; Resource recovery from wastes; waste exchanges; Composting and vermi-composting of wastes; Municipal solid waste management programs; Incineration, Sanitary landfills; Disposal – siting and design; Recycling

Hazardous Waste Treatment and Disposal: Biological and chemical treatment of hazardous wastes; Solidification and stabilization of wastes; Incineration for the treatment and disposal of hazardous wastes; Land farming; Landfill disposal of hazardous waste; Bioremediation of hazardous waste disposal sites.

Special Waste Management: Biomedical wastes, E-waste.

Laboratory Work: Biodegradable and combustible fraction of the solid waste/sludges and their calorific values; thermal, chemical and biological sludge stabilization; municipal solid waste sampling, segregation and analysis; Incineration ash analysis; Autoclaved material testing; E-waste processing; Composting and Vermicomposting.

Course Outcomes:

- Understanding and appreciating the environmental pollution and nuisense potential of municipal solid waste and of special category wastes.
- Become of aware of the regulatory requirements applicable to the handling and management of municipal solid wastes and special category wastes.
- Acquiring the knowledge of procedures, practices and technologies of management and handling (collection, reception, storage, treatment/processing, transportation and disposal) of solid wastes.
- Knowing about how sanitary landfills are designed, created, operated and closed, and about post-closure management of the landfills.

Recommended Books

1. *Pichtel J, Waste Management Practices: Municipal, Industrial and Hazardous, CRC Press (2005)*
2. *Kreith F and Tchobanoglous G, Handbook of Solid Waste Management, McGraw Hill (2002)*
3. *LaGrega M, Buckingham P and Evans J, Hazardous Waste Management, McGraw Hill (1994)*
4. *Freeman H, Standard Handbook for Hazardous Waste Management, McGraw Hill (1989)*
5. *Pollution Control Acts, Rules and Notifications Issued Thereunder: Pollution Control Law Series, Central Pollution Control Board, New Delhi (1986)*

PEV304 INDUSTRIAL WASTE MANAGEMENT

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- Facilitate understanding how industrial units are analyzed for identifying, characterizing and quantifying the wastes generated by them.
- Define the environmental management systems applicable to various process industries

Industrial Wastes and Waste Management Strategies: Industrial facilities; sources and types of industrial wastes; regulatory requirements applicable to industry; End of the pipe approach to waste management; integrated and multimedia approach to waste management and USEPA waste management hierarchy; source reduction; recycling and reuse; byproducts and resources recovery; and waste treatment and disposal; pollution prevention programs; waste management systems.

Waste Management Approach: Process mapping approach and identification of wastes; Core industrial activities and the associated wastes; Supporting activities/systems (utilities and services) of industry and the associated wastes; Characterization and quantification of wastes (monitoring, flow measurement and sampling and analysis of wastes).

Treatment Technologies Overview: Wastewater treatment and disposal technologies; Air pollution control technologies; and technologies for the treatment and disposal of solid and hazardous wastes.

Industrial Wastes Management Case Studies: Dairy industry; Pulp and paper industry; Textile dying industry; Fermentation, Sugar industry; Pharma Industry, Distillery industry; Tannery industry; and Metal Plating industry.

Laboratory Work: Field visits to industrial facilities; Environmental process mapping; Environmental sampling; Treatability studies; Pilot scale evaluations; Flow measurement.

Course Outcomes:

- Skill to develop process mapping pertinent to various industrial processes
- Ability to formulate and define waste management protocols for core industrial activities
- Possess ability to know and analyze the environmental regulatory requirements applicable wastes generated by to the industrial units.

Recommended books/weblinks

1. *Industrial Wastewater Management, Treatment, and Disposal. WEF Manual of Practice No. FD-3: Water Environment Federation; WEF Press, Mc Graw Hill (2006)*
2. *http://moef.nic.in/modules/rules-and-regulations*
3. *Pollution Control Acts, Rules and Notifications Issued There under: Pollution Control Law Series, Central Pollution Control Board, New Delhi.*
4. *Nemerow NL, Industrial Waste Treatment: Contemporary Practice and Vision for the Future, Elsevier (2006)*

PEV305 WATERSHED MANAGEMENT

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- Provide guidance on direction for assessment and development of water potential of regimes
- Facilitate understanding of approaches for maintenance of watershed based ecosystem
- Develop ability to apply theories underlying the solutions for practical problems of watershed

Introduction: Concept of watershed development, objectives, need, integrated and multidisciplinary approach.

Characteristics of Watershed: Size, shape, physiography, slope, climate, drainage, land use, vegetation, geology and soils, soils, hydrology and hydrogeology, socio-economic characteristics, basic data on watersheds.

Erosion and Measures to Control Erosion: Erosion: types, factors affecting and effects of erosion, estimation of soil loss due to erosion (universal soil loss equation); Erosion control measures: contour techniques, ploughing, furrowing, terracing, gully control, rockfill, dams, brushwood dam, Gabion.

Water Harvesting: Rainwater harvesting, catchment harvesting, harvesting structures, soil moisture conservation, check dams, artificial recharge, farm ponds, percolation tanks.

Land Management: Land use and land capability, classification, management of forest, agricultural, grass land and wild land, reclamation of saline and alkaline soils.

Ecosystem Management: Role of ecosystem, crop husbandry, soil enrichment, inter, mixed and strip cropping, cropping pattern, sustainable agriculture, biomass management, dry land agriculture, silvipasture, horticulture, social forestry and afforestation.

Water Bodies and Aquatic Ecosystems: Influence of ponding on water quality; Thermal stratification and mixing; Eutrophication and water weeds; Sediment-water interactions; Effects of waste disposal and pollution; Fate of pollutants discharged into water bodies; Self cleansing capacities of water bodies.

Human Interventions for Water Quality Management: People participation, preparation of action plans, administrative requirements; Management of catchments/watersheds and prevention of pollution; Flood control; Wetlands and constructed wetlands, and control of weeds and nutrient removal; River basin management system; Satluj river action plan; Ganga action plan.

Laboratory Work: Permeability, percolation and leaching studies; Rainfall and storm data analysis; surface run off and hydrograph analysis; vegetation analysis (productivity, dominance and diversity analysis).

Course Outcomes:

- Acquiring capabilities to demarcate and characterize watersheds
- Acquiring the capabilities to analyze the watersheds and understand the issues and concerns associated with them, and to frame the watershed management objectives
- Enabling to understand and analyze the hydrological and remote sensing data
- Having knowledge of the best management practices for the sustainable management of watershed

Recommended books

1. *Nathanson JA, Basic Environmental Technology , Prentice-Hall (2002)*
2. *Murthy JVS, Watershed Management, New Age International (1998)*
3. *Awurbs R and James WP, Water Resources Engineering, Prentice Hall (2001)*
4. *Murthy VVN, Land and Water Management, Kalyani Publications (2009)*
5. *Majumdar DK, Irrigation and Water Management , Prentice Hall (2000)*

PEV306 AGRICULTURE AND ENVIRONMENT

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- Provide understanding of the mechanism of interactions between biotic and abiotic components in agricultural systems
- Inculcate knowledge on water management by using different techniques of irrigation patterns and by crop rotations
- Develop potential to frame strategies for sustainable agriculture through economically viable and environmentally sound approaches

Soils: Cultivation; Major problems associated with the soils (Loss of soil fertility, Soil erosion, Salinity and sodicity, Soil structural decline, Soil acidification, and Build up of chemical residues); Impacts on soil oranic carbon and soil biotic community; soil conservation measures.

Crops and cropping patterns: Food, fodder, energy and fiber crops; Impacts on biodiversity.

Irrigation and water management: Water logging; Salinization; agricultural drainage and pollution of water bodies and ground water pollution; Irrigation by treated effluent; drip irrigation; sprinkler systems of irrigation.

Chemicals in agriculture: Pesticides and inorganic fertilizers; Integrated pest control; biofertilizers and biopesticides; Organic farming; composting and vermicomposting; Ecological farming; Limited till and no-till farming.

Agricultural residues and wastes: Integrated agricultural systems; Biomass fuels (anaerobic digestion, biodiesel, etc.); fiber source;

Sustainable agriculture: Green revolution and its impact; Impact of climate change on agriculture; unsustainable features of different agricultural practices; Nature and importance of sustainable agriculture; Sustainability concepts for the management soil, water, plants and animals, and for the control of weeds, pests and diseases; Examples of farming practices that are economically viable, environmentally sound and socially responsible, Green house culturing and Urban agriculture**.**

Laboratory Work: Sodium absorption ratio, chlorides, heavy metals, soil texture, ion exchange capacity, soil respiration and green house gas emissions.

Course Outcome:

- Understand the current agricultural practices and their environmental implications
- Gain insights into strategies for ecologically sound and sustainable agriculture

Recommended books

1. *Mason J, Sustainable Agriculture, Land links, (2003) 2nd ed.*
2. *Vandermeer JH, The Ecology of Agroecosystems, Jones and Bartlett (2011)*

PEV307 ENVIRONMENTAL BIOTECHNOLOGY

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- Explores the application of environmental microorganisms, products and processes within the environmental biotechnology sector for the benefit of both human society and the environment.
- Develop competence to develop bioremediation strategies for mitigation of important pollutants in environment

Scope of environmental biotechnology: Microbes and environmental management; Biodegradation of macromolecules; Composting and Vermi-composting; Heavy metal pollution; spilled oil and grease deposits and synthetic pesticides; Biopesticides; Biosensors to detect environmental pollutants; Bioindicators; Biofertilizers; Microorganisms and organic pollutants; Extremophiles. Fermentation technology (Bioreactors)

Biodegradation and bioremediation: Need of Bioremediation, Biomarkers; Genetically modified organisms for bioremediation; Mechanisms of biodegradation/bioremediation; Microbial remediation of heavy metals; Non-chlorinated SVOCs (PAHs) and VOCs (BTEX); Chlorinated SVOCs (organic pesticides) and VOCs, explosives/propellants

Factors influencing the bioremediation; In-situ bioremediation (bioventing, biosparging, bioaugmentation, etc.); Ex-situ bioremediation (landfarming, composting, biopiles, bioreactors, etc.); Engineering of bioremediation.

Applications of environmental biotechnology: Bioenergy; ethanol fermentation; Biofilters, activated sludge systems; membrane bioreactors. Biotechnological approaches for solid waste management, Phytotechnology-terrestrial phytosystems, metal phytoremediation, Phytotechnology-aquatic phytosystems, nutrient film techniques, algal treatment systems.

Laboratory Work: Isolation, purification and culturing of microorganisms of bioremediation; sampling and analysis of contaminated environments; Study of fermenter; Production of ethanol, lactic acid.

Course Outcomes

- Able to explain the applications of microbial diversity in environmental systems, processes and biotechnology
- Potential to frame strategies of ecologically and economically feasible bioremediation processes
- Analyze the biotechnological solutions to address environmental problems including pollution, solid waste, renewable energy and water recycling

Recommended Books/weblinks

1. *Evans, G.M. and Furlong J.C. 2003. Environmental Biotechnology: Theory and Application. John Wiley and Sons.*
2. *Bioremediationits Applications to Contaminated Sites in India- Ministry of Environment and Forests, Govt. of India (moef.nic.in/downloads/public Information/Bioremediation Book.pdf)*
3. *Fulekar MH, Bioremediation Technology,Capital Publishing (2010) 1st ed.*

4. *Alexander M, Biodegradation and bioremediation, Academic Press (1999).*
5. *Metcalf and Eddy (Eds). 2003, Wastewater Engineering: Treatment and Reuse, Tata McGraw-Hill, New Delhi.*

PES305 ENVIRONMENTAL SAFETY AND MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

To understand the methods of identification, classification and characterization of different hazardous materials and wastes; to know about the rules and regulations pertaining to the handling and management of hazardous materials and wastes; to understand the occupational health and safety management systems and their essential elements; and to impart awareness on noise pollution and control and on personal protection equipment.

Course Contents:

Hazardous Materials: Definition and classification; Material safety data sheets; Handling of hazardous materials.

Regulations: Rules and regulations pertaining to the management and handling of hazardous chemicals; Hazardous wastes; Biomedical wastes; Hazardous microorganisms; Genetically engineered organisms or cells; Municipal solid wastes; E-wastes; Batteries and plastics.

Hazard Identification: Assessment of risk; Risk management; OSHAS 18001 and Occupational health and safety management systems.

Principles of Accident Prevention: Accident recording; Analysis; Investigation and reporting; On-site and off-site emergency preparedness and response plans; Rules and regulations dealing with chemical accidents.

Protection from Hazardous Materials: Personal protective equipment and clothing; Fire safety; Noise and vibrations; Principles of noise control.

Safety Management: Safety audits; Material safety data sheets; On-site and off-site emergency plans; Environmental risk analysis; preparation of safety reports and notification of sites.

Course Learning Outcomes (CLOs):

The students will be able to:

- identify, classify and characterize different hazardous materials and wastes
- implementation of the rules and regulations pertaining to the handling and management of hazardous materials and wastes
- develop the emergency preparedness and response plans and programs with the ability to identify hazard and risk assessment
- cover the basic aspect of the occupational health and safety management systems and their essential elements

Recommended Books/weblinks

1. *Central Pollution Control Boards. Pollution Control Acts; Rules and Notifications Issued Thereunder. Pollution Control Law Series (PCLS/02/2006)*
2. *Gustin JF, Safety Management: A Guide to Facility Managers; Taylor & Francis (2003)*
3. *http://moef.nic.in/modules/rules-and-regulations*

PEV309 URBAN ENVIRONMENTAL MANAGEMENT

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- To understand the concepts of urban sanitation, urban material and transport management system.
- To know the issues related to municipal solid waste, e-waste and sewage management.
- To know the concepts and issues related to urban lifestyles and transport system.

Urban Water Management: Water supply; Plumbing; Urban sanitation; Sewage management; and Storm water management.

Materials Management: Municipal solid waste management; Biomedical waste management; Construction waste management; E-waste management.

Urban Environmental Management: Urban lifestyles and life style related diseases; Management of residential, commercial and institutional environment; Urban slums; Lighting, ventilation and space heating/cooling; communication systems and transmission towers, Urban agriculture and urban forestry**;** GRIHA norms; Concept of Green Building, LEED auditing; Smart Cities

Urban Transport: Transportation, energy and environment; Tail pipe emissions; Urban noise pollution problems.

Laboratory Work: Tail pipe emissions monitoring; Storm water analysis; Urban noise monitoring; Ambient air and indoor air monitoring.

Course Outcomes

- Ability to understand the problems arises due to water and sanitation problems in urban areas.
- Get acquainted with the environmental impacts of transport on urban lifestyles.
- Knowing the issues related to material and waste management in urban areas.

Recommended books

1. *Hanaki K, Urban Environmental Management and Technology, Springer (2008)*
2. *Flintoff F, Management of Solid Wastes in Developing Countries, W.H.O. Publications (1976)*
3. *Bhide R and Sundarasan BB, Solid Waste Management in Developing Countries, Insdoc Publication, (1991)*
4. *Peavy R and Tchobanglous, G, Environmental Engineering, McGraw Hill Publications (1985)*
5. *Manual on Water Supply and Treatment: Ministry of Urban Development; Government of India, New Delhi.*