PROCEEDINGS OF THE FIRST RECONSTITUTED BOARD OF STUDIES IN ENVIRONMENTAL SCIENCES (PG)

Date: 06/12/2022
Venue: DOS & R in Environmental Sciences, Tumkur University, Tumkur 572103

Chairman:
Dr. R.G. Sharathchandra: Physical Presence

Members:
Prof. S.Srikantaswamy: Physical Presence
Prof. Yogendra K: Physical Presence
Prof. B C Nagaraja: Physical Presence
Dr.Rajanaika H: Online
Ranjan Hebbar: Online
Prof. Rama Rao Nidamanuri: special invitee: Online
Prof. Sunil Nautiyal: special invitee: Online
Dr. Priya Narayan: special invitee: Online

AGENDA:
Discussion and approval of:

- Change in the title of the programme
- Eligibility criteria for admission
- Skill based value added certificate programmes
- Panel of examiners
- Approval of MOU, EHS Pvt Ltd and Metamorphosis
- Permission to Department Council to design course structure and curriculum for bridge and foundation courses.

Proceedings:

- The chairman of the board welcomed the members and explained to member's strategic approach, followed to revise the curriculum and prepare the draft.
- The board discussed the draft after considering the strategic approach.
- Board undertook the screening of the curriculum and structure of the value added courses.
- Board also studied the profile of EHS Pvt Ltd and Metamorphosis
- Board also discussed the list of Examiners.

Recommendations of the BOS:

- Change in title of the programme M.Sc Environmental science to M.Sc Ecology and Environmental science has been approved.
- Question paper pattern & Evaluation rubrics presented to the board has been approved.
- Eligibility criteria has been approved
- Structure, curriculum and Evaluation pattern for skill based valued added certificate programme has been approved.
- Panel of Examiners has been approved. The board authorized the chairman and the convener to make further inclusions when necessary.
- MOU with EHS Pvt Ltd and Metamorphosis for offering value added course has been approved. The board authorized coordinator of the department to take further necessary statutory approvals from the university.
- Board also permitted the department council to design bridge/ foundation course structure and curriculum when necessary.

Course Structure & Revised Syllabus
Choice Based Credit System (CBCS)
M.Sc. Ecology and Environmental Science

Eligibility Criteria: General candidates who have passed a B.Sc degree in any branch of science of this University or any UGC recognized higher education institution with 45% aggregate in core/cognate subjects and SC/ST candidates with 40% aggregate in core/cognate subjects shall her eligible for admission to M.Sc degree course in Ecology and Environmental Science.

Further, candidates who have passed Bachelor of Science in Agriculture and its allied subjects, Bachelor of Forestry Science (B.FSc) and its allied subjects, Bachelor of Horticulture (B.Sc Horti) and its allied subjects. Also, students who have passed BE/B.Tech with Environmental Science or Environmental Engineering as a core/cognate subjects (45% overall in the core/cognate subjects for General candidates and 40% overall in the core/cognate subjects for SC/ST Candidates) from any UGC recognized higher education institution are eligible for admission to M.Sc degree course in Ecology and Environmental Science of Tumkur University.

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Strategic Approach for the Programme will include:

Environmental Science as a discipline has emerged into a truly inter and trans disciplinary science, Studying science of the environment in the current scenario must take in to consideration science, society, policies, responses and their interactions and its impact as a whole. Therefore, the current scenario demands that a balance be established between principles of ecology, environment and various advancement that have taken place the world over. Thus, this revision will combine advancements in the field of Ecology and Environmental science while designing the Program and their respective curriculum. The curriculum lays focus on creating new knowledge, acquiring new skills and capabilities for students studying Ecology and Environmental Science. The curriculum lays additional emphasis in providing opportunities to understand the integration of modern disciplines such as Environmental Modelling, GIS and Remote Sensing, Environmental Sustainability, Corporate governance and their applications. Students would be encouraged to go beyond the classroom and conduct active action-research, research projects, technology-based learning and internships in industry/private/government/manufacturing and service sectors based on suitability. The eligibility criteria have been expanded to make interdisciplinary. Therefore, it is essential that curriculum of MSc. Ecology and Environmental Science is revised to make it relevant dynamic that will create an ecosystem for skill development, entrepreneurship and academic excellence. Tumkur University PG CBCS regulation and course pattern has been specially followed while undertaking the current revision. The current revision has taken into account draft model curriculum released by EHS on various subjects as well as latest developments in different niches of environment.

Programme Outcomes:

Objectives of the M.Sc. Environmental Science is to

- Develop industry leading professionals who can critically analyse Environmental problems and suggest Sustainable solution.
- Develop inter and Trans disciplinary thinking towards achieving Environmental Sustainability.
- Develop student's research and Entrepreneurship potential.

The pedagogical methods for the programme will include:

- Orientation classes
- Extension and Enrichment Activity
- Case study Analysis
- Group projects
- Journal clubs
- Industrial visit
- Field work Practical's
- Field and Industrial visit
- Special lectures and Seminars
- Environmental Campaigns
- Environmental Awareness Programmes
- Field Ecological studies
- Do your own Experiments
- Extension and Enrichment activity
- Mock interview Skills

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COURSE STRUCTURE AND CURRICULUM

I SEMESTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-1.1	Ecology and Ecosystem Services	4	4	3Hrs	20	80	100
2	CPT-1.2	Environmental Chemistry	4	4	3Hrs	20	80	100
3	CPT-1.3	Earth and Atmospheric Science	4	4	3Hrs	20	80	100
4	SPT-1.4A	Ecotoxicology	4	4	3Hrs	20	80	100
	SPT-1.4B	Energy Resource Management	4	4	3Hrs	20	80	100
5	CPP-1.5	Practical based on Environmental Biology and Ecosystem Services	4	2	3Hrs	10	40	50
6	CPP-1.6	Practical based on Environmental Chemistry	4	2	3Hrs	10	40	50
7	CPP-1.7	Practical based on Earth and Atmospheric Science	4	2	3Hrs	10	40	50
8	SPP-1.8A	Practical based on Ecotoxicology	4	2	3Hrs	10	40	50
	SPP-1.8B	Practical based on Energy Resource Management	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600

Note:

CPT: Core paper Theory

CPP: Core paper Practical

SPT: Special paper Theory

SPP: Special Paper Practical

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II SEMESTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-2.1	Forest and Wildlife Management	4	4	3Hrs	20	80	100
2	CPT-2.2	Environmental Pollution and Control	4	4	3Hrs	20	80	100
3	SPT-2.3A	Natural Disasters and Risk Assessment	4	4	3Hrs	20	80	100
	SPT-2.3B	Solid Waste and Processing Technologies	4	4	3Hrs	20	80	100
4	OEPT-2.4	Man and Environment	4	4	3Hrs	20	80	100
5	CPP-2.5	Practical based on Forest and Wildlife Management	4	2	3Hrs	10	40	50
6	CPP-2.6	Practical based on Environmental Pollution and Control	4	2	3Hrs	10	40	50
7	SPP-2.7A	Practical based on Natural Disasters and Risk Assessment	4	2	3Hrs	10	40	50
	SPP-2.7B	Practical based on Solid Waste and Processing Technologies	4	2	3Hrs	10	40	50
8	OEPP-2.8	Man and Environment	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600
	Compulsory Skill Based Value Added Certificate Programme- OCCUPATIONAL HEALTH AND SAFETY (Non-Credit).							

Note:

CPT: Core paper Theory **CPP:** Core paper Practical

SPT: Special paper Theory **SPP:** Special Paper Practical

OEPT: Open Elective paper theory **OEPP:** Open Elective Paper Practical

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III SEMESTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-3.1	Conservation Genetics	4	4	3Hrs	20	80	100
2	CPT-3.2	Geospatial Techniques	4	4	3Hrs	20	80	100
3	SPT-3.3A	Restoration Ecology	4	4	3Hrs	20	80	100
	SPT-3.3B	Microbial Biotechnology for Pollution Abatement	4	4	3Hrs	20	80	100
4	OEPT-3.4	Climate Change and Sustainability	4	4	3Hrs	20	80	100
5	CPP-3.5	Practical based on Conservation Genetics	4	2	3Hrs	10	40	50
6	CPP-3.6	Practical based on Geospatial Techniques	4	2	3Hrs	10	40	50
7	SPP-3.7A	Practical based on Restoration Ecology	4	2	3Hrs	10	40	50
	SPP-3.7B	Practical based on Microbial Biotechnology for Pollution Abatement	4	2	3Hrs	10	40	50
8	OEPP-3.8	Practical based on Climate Change and Sustainability	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600
	Compulsory Skill Based Value Added Certificate Programme- TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT (Non-Credit).							

Note:

CPT: Core paper Theory CPP: Core paper Practical

SPT: Special paper Theory SPP: Special Paper Practical

OEPT: Open Elective paper theory OEPP: Open Elective Paper Practical

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IV SEMESTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-4.1	Environmental Impact Assessment, Policies and Laws	4	4	3Hrs	20	80	100
2	CPT-4.2	Research Methodology, Scientific Communication, and Environmental Entrepreneurship	4	4	3Hrs	20	80	100
3	SPT-4.3A	Urban Ecology And Smart Cities	4	4	3Hrs	20	80	100
	SPT-4.3B	Science Of Climate Change and Global Policies	4	4	3Hrs	20	80	100
4	CPPD-4.4	Project Dissertation	4	4	3Hrs	20	80	100
5	CPP-4.5	Practical based on Environmental Impact Assessment, Policies and Laws	4	2	3Hrs	10	40	50
6	CPP-4.6	Practical based on Research Methodology, Scientific Communication, and Environmental Entrepreneurship	4	2	3Hrs	10	40	50
7	SPP-4.7A	Practical based on Urban Ecology And Smart Cities	4	2	3Hrs	10	40	50
	SPP-4.7B	Practical based on Science Of Climate Change and Global Policies	4	2	3Hrs	10	40	50
8	CPPP-4.8	Practical's Based on Project	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600

Note:

CPT: Core paper theory
SPT: Special paper theory
CPPD: Core paper project Dissertation
CPP: Core paper practical
SPP: Special paper practical
CPPP: Core paper project practical

The number of experiments for CPP/SPP papers may vary for each semester. A core set of common experiments will be retained for each CPP/SPP paper and up to 50% changes will be carried out in the number and nature of experiments. These changes will be carried out after evaluating recent research articles, availability of Lab kits / Consumables / Protocols and virtual demonstration tools at the beginning of each Semester.

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CURRICULUM

I SEMESTER

CPT-1.1: ECOLOGY AND ECOSYSTEM SERVICES

Course Objectives:

The objectives of this course are to sensitize the students to:

- Provide Knowledge about developmental phases of ecology and ecological classification.
- Develop knowledge of population and Community ecology.
- Key ecosystem service concepts and their applications.

Student Learning Outcome:

At the end of the course, students should be able to:

- Make connections and interrelations between various disciplines in the environment.
- Explain the function and impact of flow of energy and structure of ecosystem.
- Describe ecological and statistical techniques and approaches used in the study of environmental biology.
- Understand the benefits provided to humans through the transformations of resources into a flow of essential goods and services of ecosystem services.

Unit I: Basic Principles of Environmental Biology

Introduction to Environmental biology; Concepts of Environment; Multidisciplinary nature of Environmental Science; Components of Environment; Scope and Importance of Environmental Science; Ecology- Principles of ecology (Adaptation, Variation, Adaptive Speciation Natural selection, Evolution and Extinction); Levels of Organizations in ecology; Human Ecology and Settlement.

Unit II: Ecosystem Functions and Structure

Introduction to Ecosystem; Components of Ecosystem- Biotic components (Producers, Consumers and Decomposers) and Abiotic components; Functions of Ecosystem - Flow of Energy (Food chain, Food web and Food Pyramids), Ecological Succession, Biogeochemical Cycles (Gaseous Cycles – Nitrogen, Carbon, Oxygen and Carbon cycles, Sedimentary Cycles- phosphorus cycle, sulphur cycle, calcium cycle, magnesium cycle), Homeostasis; Structure of Ecosystem - Terrestrial Ecosystem(Forest ecosystem, Grassland ecosystem and Desert ecosystem) and Aquatic Ecosystem(Saline water - Oceans ecosystem, Brackish water- Estuaries and Mangrove ecosystem and Fresh water - Pond/ lake, Wetlands and River ecosystem);Ecosystem Productivity.

Unit III: Population and Community Ecology

Population Ecology - Definition; Characteristics of population; concept of carrying capacity; population growth and regulations; Population fluctuations, dispersion and metapopulation. Concept of 'r' and 'k' species; Keystone species. Community ecology – Definition; Community concept; Types and ecological interaction (predation, herbivory, parasitism, Competition, Commensalism, Amensalism, Mutualism, Neutralism and allelopathy); Biological invasions.

Unit IV: Ecosystem Services

Introduction to Ecosystem services; Categories (Regulating service, Provisioning service, Cultural service and Supporting service); Key ecosystem service concepts and their applications; Ecological Service (Redundancy hypothesis, Rivet hypothesis and Portfolio effect); Economic Values (Avoid cost, Replacement cost, Factor cost, Travel cost, Hedonic Pricing, and contingent valuation).

CPT-1.2: ENVIRONMENTAL CHEMISTRY

Course Objectives:

The objectives of this course are to sensitize the students to:

- Impart knowledge on the fundamentals of chemical process
- Understand the environmental problems
- Study for solving various environmental issues
- Familiarize with the water analysis techniques to analyze acidity and alkalinity
- Understand the basics of soil analysis

Student Learning Outcome:

At the end of the course, students should be able to:

- Develop concepts of basic chemistry associated with the occurrence of environmental pollutants.
- Understand various chemical constituents present in air and water, interactions among them and manner in which changes are brought about due to pollution.
- Analyze the toxic chemical behavior in environment.
- Familiar with the latest green chemistry principle and applied in daily life for pollution reduction.

Unit I: Chemistry of the Environment

Fundamental of environmental chemistry: Mole Concept, Solution chemistry, solubility product, Solubility of gases, Laws of thermodynamics: heat transfer processes, Gibbs' free energy; heat transfer processes, Chemical potential Chemical kinetics and chemical equilibrium; Electrochemistry and redox reactions. Sources of radiations. Radioisotopes and other radionuclides in the environment, unsaturated and saturated hydrocarbons.

Unit II: Air and Water Chemistry

Atmospheric Chemistry: Composition of air; particles, ions and radicals in atmosphere, formation of particulate matter, Photo-chemical reactions in the atmosphere, thermal inversion, photochemical smog, acid rain, chemistry of ozone layer depletion; greenhouse gases and global warming. Aquatic chemistry: Structure and properties of water, Water quality parameters, Physicochemical concepts of colour, odour, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, Solubility of gasses, carbonate system, redox potential.

Unit III: Soil and Geochemistry

Soil Chemistry: Physio-chemical composition of soil, humus, Inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, Cation exchange capacity (CEC), Environmental geochemistry: Concept of major, trace and REE. Classification of trace elements, Solubility and mobility of trace elements; Biochemical aspects of Arsenic, Cadmium, Lead, Mercury, Carbon monoxide, O3, PAN, MIC and other carcinogens.

Unit IV: Instrumentation Techniques

Spectrometry, UV-Vis and IR spectrophotometer and AAS, flame spectrometry and fluorimetry; Chromatographic techniques: Paper, Thin Layer, Gas and Gas – Liquid Chromatography, HPLC, X-ray fluorescence, x-ray diffraction, Electrophoresis, NMR and Mass Spectrometry. Principles of Gravimetry, Titrimetry and Colorimetry.

CPT-1.3 EARTH AND ATMOSPHERIC SCIENCE

Course Objectives:

The objectives of this course are to sensitize the students to:

- Impart knowledge on the fundamentals of natural environment
- Understand the Earth, Geochemistry, Mineral and Water resources of the environment
- Study about the Earth Systems and Biosphere
- Describe the chemical composition and possible origins of our atmosphere.
- Impart the basic and advanced knowledge of various processes and phenomena in the field of Atmosphere Science and Meteorology.
- Acquire basic knowledge of earth's resources and its optimum utilization for sustainable development.

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand the basics of the Earth's structure, composition and evolution of landforms
- Analyze the effects of meteorological parameters on the dispersion of pollutants.
- Understand and apply the basic concepts of meteorology, climatology and oceanography for solving relevant environmental issues.
- Students will be able to Analyze role of Plate Tectonics in Various Earth Surface Processes.
- Students will be able to Evaluate the role of different types of Rocks in Rock Cycle and significance of Weathering and Erosion over Earth Surface.
- Evaluate the role of Atmosphere - Ocean, Atmosphere- Land & Ocean- Land Interface in Earth Surface processes.

Unit I: Earth Systems and its Interaction

Lithosphere, Hydrosphere, and Biosphere, Formation of the Earth System, Earth Interior, chemical composition of Earth; – Distribution and abundance of elements in the major Units of Earth, Geochemical features, Formation, and classification of Minerals and Rocks. Folds, faults, dykes and other geological formations and their environmental significance.

Unit II: Mineral Resources and Pedology

Geological features of India and Karnataka. Land-use planning and Terrain evaluation. Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; Soil characteristics, formation of soil, role of soil organisms in soil formation, soil erosion, types, soil conservation. Elemental Pathways - geochemical cycles. Biogeochemical factors in environmental health and effects of imbalance.

Unit III: Evolution and Development of Atmosphere

Atmospheric structure and composition; significance of atmosphere in making the Earth, Milankovitch cycles; Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; greenhouse gases (GHGs); greenhouse effect, GWP. Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; El Nino and La Nina; Tropical cyclone.

Unit IV: Ocean Circulation

Northeast and Southwest monsoon winds; ocean surface circulation; equatorial current systems; under currents; circulation in Arabian Sea and Bay of Bengal; The Coriolis force, Atmospheric Turbulence, General Turbulence theory, isotropic turbulence, geostrophic turbulence, lapse rate and stability, scale height, geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes.

SPT-1.4A ECOTOXICOLOGY

Course Objectives:

The objectives of this course are to sensitize the students to:

- Understand the occurrence and route of entry of various environmental toxicants and contaminants
- Know the general modes of action of toxicants affecting organisms.
- Learn the mechanisms of organisms that defend against natural and synthetic toxicants, and the consequences of these for species-selective action of toxicants.
- Similarities and dissimilarities between natural and synthetic toxicants and their impact on organisms.
- Estimate the health risks associated with exposure to xenobiotics in the environment

Student Learning Outcome:

At the end of the course, students should be able to:

- Gain knowledge on various environmental toxicants – toxicants in food, drugs, pesticides and PPCP's etc.
- Improve understanding about the negative effects of organic and inorganic toxicants on life of organisms and on environment
- Gain knowledge on the exposure routes of toxicants, toxicological test methods, and determination of toxic levels of contaminants
- Understand the importance of toxicological regulations and will be able to explain the potential fate and effects of a contaminant in the environment
- Understood the importance of animal ethics to be followed in toxicological testing methods and option for alternative test methods

Unit I: Environmental Toxicology

Definition and branches of toxicology, scope and importance of toxicology, Principles of toxicology. Toxicants - Classification, routes of entry, transport, storage, metabolism, and excretion. Categories of toxic effects - synergistic, antagonistic, and additive effects. Acute and chronic toxic effects. Dose-effect and dose response relationships, LOAEL, and NOAEL.

Unit II: Hazardous Waste and Metabolism of Toxicants

Hazardous effect – Polychlorinated biphenyls (PCBs), Persistent organic pollutants (POPs) and biohazards. Toxicity of pesticides, insecticides, fertilizers, heavy metals, radioactive substance, fluorides, and carbon monoxide. Mode of action of toxicants, mechanism of toxicants - Biochemical and molecular effects. Bioconcentration, bioaccumulation and biomagnification of toxicants.

Unit III: Analytical Methods for Toxicity Testing

Model ecosystems - microcosms and mesocosms, Biosensors and bio-markers in toxicology. Molecular marker to toxicants - metabolites as indicators, protein induction, cytochrome P450 enzymes, stress proteins and metallothionein's. Toxicity: case studies (F, As, Hg etc.), entry, movement and fate (biotransformation, bioaccumulation and biomagnifications) of pollutants in ecosystems, natural toxins: animal toxins, snake venoms, plant toxins, metals, pesticides, POPs: portals of entry and toxic effects, chromosome damage, gene mutation, factors influencing toxicity, environmental carcinogenesis: chemical carcinogenesis, organic carcinogens, metal carcinogens, occupational cancer, toxicity testing, test organisms used in bioassays, coliform bacteria count and MPN method, dose response curves, LC50,LD50.

Unit IV: Environmental Risk and Health

Environmental and occupational safety - Definitions, concept and scope, occupational exposure, occupational hazards, and diseases. Control of toxic materials and protection measures - air, water, and soil. Health effects of cosmetics and pharmaceuticals products, occupational health hazards-Pneumoconiosis, Bagassorsis, Byssicosiss, Asbestosis, Anthracosis, Siderosis, farmers lungs. Legislative perspective in ecological risk assessment, human health risk assessment.

SPT-1.4B: ENERGY RESOURCE MANAGEMENT

Course Objectives:

The objectives of this course are to sensitize the students to:

- Provide students with a general awareness on the importance of energy and its conservation, its impact on society, various energy sources, energy conversion processes, energy management, energy audit and energy conservation measures.
- Understand conventional and nonconventional fuels & combustion technology.
- Understand the biomass energy conversion resources and technologies.

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand the fundamental for Non-Conventional and conventional Energy Sources.
- Design and optimization of Solar Energy based technologies and applications
- Learn Fundamentals and calculations for biogas and biomass-based power generation systems.
- Scientific overview the wind and hydro power systems and its associated problems.
- Fundamentally understand Tidal, Geothermal and Nuclear Energy based systems and its Applications.
- Learn special skills particularly on the load management and control strategies.

Unit I: Energy, Demand and Energy Resources

Defining energy; forms and importance; fossil fuels, advent of nuclear energy, global energy resources; renewable and non-renewable resources: distribution and availability; future technologies for capturing and integrating these resources into our energy infrastructure; energy use scenarios in rural and urban setups; energy conservation. Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; energy subsidies and environmental costs.

Unit II: Energy from Waste Bio-chemical Conversion

Growing energy needs, Renewable and non-renewable sources, use of alternate energy sources, Wind energy, Solar energy, water as source of energy, Biofuels production, use and sustainability, use and over exploitation of energy sources and associated problems. Equitable use resources for sustainable lifestyles., present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships, and villages.

Unit III: Non-renewable and Renewable Energy Resources

Oil: formation, exploration, oil shale, natural gas: exploration, liquefied petroleum gas, compressed natural gas; coal: reserves, coal gasification; environmental impacts of non-renewable energy consumption; future energy options and challenges. Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; benefits of hydropower development; nuclear fission reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; Ocean Thermal Energy Conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Unit IV: Energy Resource Management

Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources, and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

II SEMESTER

CPT-2.1: FOREST AND WILDLIFE MANAGEMENT

Course Objectives:

The objectives of this course are to sensitize the students to:

- Learn about silvicultural practices in the seed germination and nurturing to the stage of transferring to planting sites.
- Outline the management practice necessary for the improvement of the habitat, which will in turn increase the wildlife population
- Develop scientific skills for resolving human wildlife conflict including capture, handling, care and management of wild animals.

Student Learning Outcome:

At the end of the course, students should be able to:

- Gain knowledge about Role of government in wild life conservation and management.
- Improve understanding of Evolution of wildlife conservation and policies regarding protected areas.
- Gain knowledge about different types of Environmental Act. for wild life conservation.
- Understand the Importance of forest products to tribal population and tribal right in India.
- To study the importance of forests and its sustainable development.

Unit I: Introduction to Forest Ecosystem

Concept of forest ecosystem, Significance of forest, forest ecosystem structural and functioning, forest diversity indices (alpha diversity, beta diversity, gamma), Forest productivity (primary and secondary productivity), Measurement of forest productivity, Major Forest types of the world; forest types and forest cover of India. General forest protection against fire, pests and diseases, Biological and chemical control. Forest management - objectives and principles. Sustainable Forest Management (SFM) - criteria and indicators of SFM - sustained yield - concept and management.

Unit II: Fundamentals of Silviculture

Definition, history, objectives and scope, Seed production, seed periodicity, seed dispersal, seed collection and processing, seed dormancy, seed germination, methods of seed viability estimation and measurement of seed vigor; General nursery techniques. Types of forestry, Silviculture and sustainability-criteria and indicators for sustainable plantation forestry in India-CIFOR guidelines. Types of forest protection measures, Protection against deforestation, illicit felling, encroachment, mining, shifting cultivation and forest fire. Silviculture of some economically important species of India such as Pinus roxuburhii, Acacia species, Dalbergia sp. Tectona grandis, terminalia sp, etc.

Unit III: Wildlife Ecology

Definition of wildlife, Behavioral Ecology- Concepts of behavioral ecology, instinctive behavior, fixed action pattern, habituation, imprinting, memory, infanticide, reflex and complex behavior, sign stimuli, group living, altruism, reception and its types, kin selection, Polygamy, monogamy, Time- activity budgets, Ethograms, Social interaction, matrices and their analysis, pheromones. Social Organization in primates, Territoriality, Dominance, Courtship, Animal migration, Animal aggression, Animal deception, Animal inception, Plant – animal interactions, Shelter and Nesting by animals, values of wildlife.

Unit IV: Wildlife Depletion and Management

Causes for wildlife depletion, elements of wildlife management, Categories of wildlife. Wildlife conservation projects (Aims, objectives, Threats, Mitigation, success rate) Project Tiger and NTCA, Project Lion, Project Hangul, Project crocodile, Project Elephant, Project great Indian bustard, Project blackbuck, Dolphin conservation program, Olive Ridley turtle conservation program, Indian Rhino vision 2020 and Project Snow leopard. Human-wildlife conflict- Causes, impacts, reason behind the human and wildlife interaction. Role of organizations; WWF, WII, IBWL, ICFRE, TRAFFIC, WCS and NCS, BSI, ZSI, FRI, National Forest policy, Man and Biosphere (MAB) program, BNHS, Indian Institute of forest management.

CPT-2.2 ENVIRONMENTAL POLLUTION AND CONTROL

Course Objectives:

The objectives of this course are to sensitize the students to:

- Study on properties of air pollutants, air pollution sampling measurements and analysis.
- Familiarize with different control methods and adsorption of solids, liquid and gas analysis.
- Know about pollution caused by vehicle emissions and different industries.
- Get an idea on noise and thermal pollutions and their effect on human health.
- Basic concepts of different water pollutants
- Different principles of water treatment.

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand the sources and classification of Air pollutants and their impact on environment
- Know the properties of water, classification and the effects of water pollutants
- Understand the sources, sinks and broad classification, movement and sorption soil pollutants
- Gain detailed knowledge about physico-chemical and biological control methods of various air/soil/water pollutants.
- Gain more information about the causes, consequences and control measures of industrial disasters
- Understand the fundamentals of origin, impacts and control of different air pollutants.

Unit I: Air Pollution

Overview of Environmental Pollution-Definition, types of pollutants, causes, effects, monitoring, prevention and control of pollution. Air: Natural and anthropogenic sources of pollution. Primary and Secondary pollutants. Transport and diffusion of pollutants. Gas laws governing the behavior of pollutants in the atmosphere. Methods of monitoring and control of air pollution .SO2, NO2, CO, SPM. Air Quality Index, Ambient Air Quality Standards; Indoor air pollution Effects of pollutants on human beings, plants, animals, materials and on climate; Air pollution control techniques; catalytic converters, electrostatic precipitators, wet scrubbers, fabric filters and other technologies.

Unit II: Water Pollution

Water Pollution: Sources and impact of water contaminants on human health; Eutrophication; Water borne diseases; Water quality parameters and standards; Marine Pollution: sources, impacts and control; Oil spill and its effects; Coral Bleaching and Reef Degradation; Coastal Zone Management; Wastewater treatment; preliminary, primary, secondary, tertiary treatment of wastewater including other technologies.

Unit II: Radioactive & Noise Pollution

Noise Pollution: Definition, sources, and terminology; types of noise; Measurement of noise; Noise indices, noise exposure level and impact on Human beings and climate. Noise control and abatement measures. Radioactive Pollution: Definition, radioactivity, radionuclides, radiation emissions, sources, radioactive decay and buildup. Biological effects of radiation and ecosystem. Radiation exposure standards, radioactive pollution and pollution control measures. Biological dosimetry.

Unit IV: Soil Pollution

Soil Pollution – definition, sources and classification of soil pollutants and their impact on soil and plants. Chemical and Bacteriological sampling and analysis of soil quality; Soil abatement techniques and its conservation methods; Thermal pollution; concept, sources, effects and control measures for thermal pollution.

SPT- 2.3A: NATURAL DISASTERS AND RISK ASSESSMENT

Course Objectives:

The objectives of this course are to sensitize the students to:

- Educate the students about the different types of natural hazards and understand approaches
- Impart knowledge on the management, disaster preparedness and training and mitigation
- strategies during the natural disasters.
- Learn the concepts, terminologies, and developments in the field of Disaster Management and to inform them about the prospects of a Natural Disaster Management.

Student Learning Outcome:

At the end of the course, students should be able to:

- Will be able to understand and differentiate the different types of disasters, analyze the causes and their potential impact on the natural and man-made environments.
- Will be able to create awareness among the vulnerable population as a measure of disaster mitigation
- Educate people about the importance of preparedness in vulnerable areas.
- Will be able to know about the various national and international agencies that play a major role in disaster management

Unit I: Types of Disaster

Definition and Components of Disaster Management. The necessity of studying Disaster Management (DM); the scope for Disaster Management, Disaster – Definition; Types of disasters, Hazard – Definition; types of hazards; characteristic features, occurrence, and impact of different types of hazards viz. natural hazards (including geo hazards), human induced hazards, environmental hazards, bio hazards; Hazard map of India.

Unit II: Disaster Risk Mitigation

Earthquake Risk Mitigation – Earthquake, its Causes and Characteristic features; Magnitude and Intensity of earthquake; Flood Risk Mitigation – Causes of Flood; Major floods; Flood vulnerability of India; Flood preparedness and mitigation; Cyclone Risk Mitigation – Causes of Cyclone; its characteristics; Cyclone vulnerability of India; Cyclone preparedness; Forecast and early warning dissemination; Drought Risk Mitigation – Causes and characteristics of Drought; drought vulnerability of India; Drought preparedness and Mitigation. vi) Landslide Risk Mitigation – Causes and Characteristics of Landslides; Landslide vulnerability of India; Mitigation measures; Prevention measures. Role of GIS and Remote sensing in disaster risk management; Tsunami Risk Mitigation – Causes of Tsunami; its characteristics; Tsunami vulnerability of India; Tsunami preparedness;

Unit III: Disaster Risk Assessment

Ways of minimizing disaster risk – Preparedness, Mitigation and Prevention – definition, Risk analysis techniques; Process of Risk assessment, ·Disaster Risk Management (DRM) plan – Preparing Hazard-Vulnerability profile; Emergency Response and Crisis Management, Crisis Management – Rescue, relief, rehabilitation and reconstruction; Emergency response, Search and Rescue operations; Relief operations; Relief Operations – Arranging for Temporary shelter, Food, Safe drinking water, Sanitation and Medical aids; Role of NGOs and Health workers in relief operations; Recovery- Rehabilitation – Need analysis of disaster affected people; Reconstruction – Repair and reconstruction of roads, bridges, buildings, structures and establishments of damaged or destroyed in the disaster.

Unit IV: Government Initiatives for Disaster Management

Disaster Management Policy Environment and local Action – Disaster Management Act 2005; Disaster Management Authority at National, State and District levels; Roles and responsibilities of Govt. Authorities including Local Self Govt. at various levels. ii) Funding for Disaster Management – State Disaster Mitigation fund, State Disaster response fund (SDRF), National Disaster Response Fund (NDRF), Prime Minister National Relief Fund (PMNRF)

SPT-2.3B: SOLID WASTE AND PROCESSING TECHNOLOGIES

Course Objectives:

The objectives of this course are to sensitize the students to:

- Basic principles and characteristics, sources, generation, segregation, classification, and physico-chemical characterization of solid waste management.
- Concepts of Disposal of solid waste and their technologies.
- National Waste reduction policies and People's Responsibility of Waste Management.

Student Learning Outcome:

At the end of the course, students should be able to:

- Ability to demonstrate sound understanding of the waste generation process and characteristics of different types of solid wastes.
- Ability to address the waste management processes through various technologies.
- Ability to assess the underlying science behind the waste driven pollution.

Unit I: Fundamentals of Solid Waste Production

Definition of solid waste; Meaning of different solid waste -Domestic Waste, commercial waste, industrial waste, market waste, agricultural waste, biomedical waste, E-waste, hazardous waste, institutional waste; Sources of solid waste, Classification of solid waste - hazardous and non- hazardous waste.; Physical and chemical characteristics of municipal solid waste.; Impact of solid waste on environment.; Solid waste management techniques – solid waste management hierarchy, waste prevention and waste reduction techniques.; Factors affecting the solid waste generation.

Unit II: Disposal of Solid Waste

Storage of solid waste; Collection methods of solid waste; Transportation of solid waste; Concept of composting of waste- principles and methods of composting, factors affecting the composting process; Landfills: Types and Construction of landfills, Landfill Problems, Lining of landfills – Types of liners; Leachate pollution and control; Biogas from landfill; Monitoring landfills; Landfills reclamation; Advantages and disadvantages of landfill method; Landfill gas management; Recycling of municipal solid waste; Incineration of waste- Process, Types and products of incineration ; Pyrolysis of waste- Process, Types and products of incineration; Gasification process;

Unit III: Waste Analysis and its Management

Waste Analysis; Introduction to Waste Audit, Checklist for performance audit in Waste Collection, Segregation, Transport, Treatment; Responsibility of Waste Management; Polluter Pays Principle (PPP); Assimilative Capacity and the Precautionary Principle; World Scenario in Scrap Trade Extended Producer Responsibility (EPR); Carrying Capacity; Precautionary Principle; Waste Reduction at Business (Producer) Level, Waste Reduction at Individual Level: Zero Waste Living, Waste Reduction at Community Level. Waste management Policy - Municipal Solid Wastes (Management and Handling) Rules, 2000; The Hazardous Waste Management Rules, Biomedical; Wastes (Management and Handling) Rules 2016 & 2018; E-waste (Management and Handling) Rules 2016, 2019.; The Batteries (Management and Handling) Rules 2001,2016, 2020 with latest amendments; Steps taken by India regarding Solid waste- Swachh Survekshan; Star Rating of Garbage-Free Cities; Swachhata Hi Sewa Campaign; Compost Banao, Compost Apnao Campaign.

Unit IV: Biomedical, Industrial and E-Waste Waste Management and their Health Aspects

Definition, sources and generation of Biomedical waste, Classification of Biomedical waste and Management technologies; Industrial waste- varieties, collection and disposal of industrial waste, Control measures and recycling of industrial waste; E-waste management- varieties, collection and disposal of e-waste, Control measures and recycling of e-waste; Health aspects during handling and processing; Health problems during time of segregation, recovery, recycling and reuse of solid waste; Public involvement and participation in solid waste management practices.

OEPT- 2.4: MAN AND ENVIRONMENT

Course Objectives:

The objectives of this course are to sensitize the students to:

- Gain knowledge about environment and ecosystem.
- To understand about the conservation of biodiversity and its importance.
- Aware students about problems of environmental pollution, its impact on human and ecosystem and control measures.
- Students will learn about increase in population growth and its impact on environment.

Student Learning Outcome:

At the end of the course, students should be able to:

- Ability to demonstrate comprehensive understanding of the environment and examine the main limitations/ stress on patterns of productivity, energy flow through natural food webs, and ecosystems dynamics.
- To identify and quantify the magnitude and intensity of Environmental pollution problems.
- To apply critical mind in policy and approach aimed at resolving environmental issue, which, often, are with social aspects.

Unit I: Fundamentals of Environment

Definition of Environment; Concept of Ecology; Components of Environment; Multidisciplinary nature of Environmental Science; Components of Environment; Scope and Importance of Environmental Science; Ecology- Principles of ecology (Adaptation, Variation, Adaptive Speciation Natural selection, Evolution and Extinction); Levels of Organizations in ecology; Ecosystem- Components of Ecosystem, food chain and food web; Ecological Succession; Types of Ecosystems- Terrestrial ecosystem (Forest, Grasslands and Deserts) and Aquatic ecosystem (Fresh water, Marine water and Brackish water); Biogeochemical cycles.

Unit II: Biodiversity

Concepts of biodiversity; levels of biodiversity; Biodiversity hotspots; Biogeographic Zones of India; Value of Biodiversity: Consumptive, Productive Use, Social, Ethical, Aesthetic and Option Values; Measurement of Biodiversity; Threats to Biodiversity: Habitat Loss, Poaching of Wildlife, Man-Wildlife Conflicts; Conservation of Biodiversity: In-Situ and Ex-Situ; Endemic species; Red data books; Biosphere Reserve; Man, and Biosphere Programme;

Unit III: Environmental Pollution

Air, Water, Soil and Noise pollution Source, effects and control measures; Nuclear hazards and human health risks; Solid waste management - Source, effects and control measures of urban and industrial waste Pollution; Environmental Remediation Techniques- Phytoremediation and Bioremediation, In-situ and Ex-situ bioremediation and their types.

Unit IV: Communities and the Environment

Human Population density- natality, mortality; Population growth and rate, dispersion, emigration, immigration, migration, and regulation of population size; Environmental movements; Environmental ethics; Environmental communication and public awareness; Environmental Hazards and Disasters- Natural Hazards, Anthropogenic Hazards and Socio-natural Hazards; Relationship between Environment and Development;

III SEMESTER

CPT 3.1: CONSERVATION GENETICS

Course Objectives:

The objectives of this course are to sensitize the students to:

- Occurrence and distribution of various flora and fauna, their existence, interaction, Importance of biodiversity conservation and understand about Legislation related to conservation.
- Learning tools and techniques relevant to monitoring of biological diversity modern synthetic view of evolution which integrates genetics, molecular biology and many other areas of biology into an explanation of how evolution occurs.

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand basic principles of Genetics, Genetic concepts provide the framework for the study of Modern Biology.
- Learn advanced selection and screening techniques including molecular markers, PCR and sequencing.
- Learn the importance of conservation of biodiversity which serves to the mankind and the ecosystem, and the major threats to biodiversity due to human developmental activities.

Unit I: Introduction to Genetics

Concept of Gene: Allele, Multiple Alleles, Pseudo allele. Mendelian Principles: Dominance, Segregation, Independent Assortment, Deviation from Mendelian Inheritance. Extensions of Mendelian Principles: Codominance, Incomplete Dominance. Lamarck's principle.

Unit II: Molecular Genetics

DNA as genetic material- Experiments of Griffith; Avery, Mc Leod and Mc Carty; Harshey and Chase. RNA as genetic material- Experiment of Fraenkel and Singer. b. Nucleic acids: Molecular structure of DNA, Chargaff's rule, Forms of DNA- A, B and Z forms. RNA types and structure – mRNA, tRNA (clover leaf model), rRNA. Ribozymes.

Unit III: Analytical Techniques for Conservation

Molecular Techniques – Genomics (General concepts & applications) Extraction of DNA from samples, PCR & RTPCR, DNA sequencing, DNA fingerprinting, Blotting and its applications, RAPD, RFLP, AFLP, artificial insemination, artificial pollination, embryo transfer technology, plant tissue culture, culture of anther, ovule & embryo, artificial seed.

Unit IV: Planning and Implementing Conservation Programmes

Methods of conservation Ex- situ & in-situ conservation, in-situ conservation; Biosphere reserves, National parks, Sanctuaries, Sacred grooves, Protected areas. Ex-situ conservation; Botanical gardens, Zoological parks, gene and pollen banks, seed and seedling banks, cryopreservation and other methods. Traditional knowledge & cultures in conservation, Traditional Societies (e.g. Bishnois), Role of NGOs in conservation; International NGOs, GEF, WCS, Bird Life International, Important NGOs in India & their contributions, ATREE, WTI, Kalpavriksha etc.

CPT 3.2: GEOSPATIAL TECHNIQUES

Course Objectives:

The objectives of this course are to sensitize the students to:

- Study of remote sensing component and different types of platforms.
- Measurement of biodiversity interaction with environment by satellite, sensors and aerial photography.
- Monitoring forest diversity and urban sprawl analysis by Remote Sensing and GIS Technology

Student Learning Outcome:

At the end of the course, students should be able to:

- Learn about data and sources (RS based and other sources, field data) and GIS software.
- Create knowledge of Statistical analysis of geographical data structure.
- Describe application of Remote Sensing and GIS Technology.
- Build the foundation for understanding Remote Sensing and Geographic Information System (RS-GIS) as a powerful tool for geospatial analysis

Unit I: Basic Principles of Geospatial Technology

Introduction to Geospatial Technology; Components of Geospatial Technology and their relationship. Basic principles of Remote Sensing. Benefits of Remote Sensing over conventional method of resource survey. Electromagnetic energy and its interaction with matter; Black body and Real body radiation; Contrast and illumination effect on human vision; Measurement of radiation; Energy matter interaction- Refraction, scattering, absorption, reflectance. Effects of atmosphere on EMR; Interaction of EMR with atmosphere and earth's surface. Geospatial Techniques, Modelling of Earth and Environment

Unit II: GIS Platforms and Other Technologies

GIS-Definition, Historical perspective, Components of GIS and types of GIS; Technology trends in GIS, relationship between geoinformatics, information technology and sensor technology; Computer fundamentals for GIS, Hardware and software requirements for GIS; Concept of data, geographic data sources (Remote Sensing, GPS, maps and field observations); Data models: Concept and types, Raster data model, Vector data model; Data input, Databases, Database management system (DBMS).

Unit III: GPS, Survey, Thematic Mapping and Cartography

Basic concepts of Global Positioning System (GPS), accuracy and error corrections in GPS; Fundamental of mobile mapping, application of GPS in resources surveys and mapping; Concept of absolute and differential global positioning system; Types of GPS receivers, GPS satellite signal, GPS data, error correction techniques in GPS

Survey Methods - chain and compass, plane table, prismatic compass, theodolite. Maps and their classification. Map characteristics and features; Thematic symbolization; positioning of objects on map. Properties of map projection; projection types; Extrinsic and Intrinsic problems; Map reference system- latitude, longitude, and other systems. Basic principles of cartography. Cartographic communication process.

Unit IV: Applications of Remote Sensing

Microwave remote sensing – concept and principle, backscattering, cross section wavelength, incidence angle, aspect angle, aircraft radar system; Interactions between radar and surface materials - complex dielectric properties, roughness polarization; Passive & active microwave sensors; Application of microwave remote sensing and microwave image interpretation. Application of remote sensing in disaster management (landslides, flood, draught, earthquake); Applications of remote sensing in agriculture sciences (crop acreage estimation, cropping Patterns/monitoring); Applications of remote sensing in natural resources management; Applications of remote sensing in forestry and ecology. Satellites and their characteristics – geo-stationery and sun-synchronous, Indian space programme, GAGAN and NAVIC satellite navigation systems, Geospatial Portal (Bhuvan); Satellite programme of NASA

SPT- 3.3A: RESTORATION ECOLOGY

Course Objectives:

The objectives of this course are to sensitize the students to:

- Historical development of restoration concepts and the role of restoration in the future stewardship of natural resources.
- Major ecological principles underlying the successful restoration of ecosystems including concepts of disturbance and succession.
- Use of ecological and management principles and select appropriate methods and tools for designing and conducting restoration projects.

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand the various motivations and goals for ecosystem restoration.
- Learn about theories in restoration ecology and biophysical factors that influence ecosystem restoration practices and outcomes.
- Critically think about motivations, goals, planning, implementation, and outcomes of restoration.

Unit I: Introduction to Ecological Restoration

Background and introduction to Ecological Restoration: Historical development, Role in stewardship, Future needs; Ecological Concepts: Ecological Succession, Reference conditions; Restoration Process: Steps in the Process, Understanding Limitations- Biological Limitations, Physical Limitations, Chemical Limitations; Overcoming Limitations (a few examples) - i) Revegetation ii) Mulching iii) Equipment iv) Bioremediation v) Collaborative Restoration; Restoration in Various Settings (examples)- Wetlands, Rivers, Wildlife, Temperate Forests, Grasslands, Tropical Forests;

Unit II: Integration of Ecological Restoration into a Larger Program

Legal, policy and governance aspects; Assessment of Opportunities and priorities for restoration; Cost benefit analysis, accounting processes and resource mobilization; Strategic planning processes; Selection and implementation of restoration interventions; Monitoring and evaluation; Capacity-building and development; Restoration in the context of large-scale initiatives and agreements; Understand the steps and activities involved in developing a plan for ecosystem restoration; Tailor your restoration plan based on real-world examples; Conceptualize the application of the Short-Term Action Plan on Ecosystem Restoration in your context

Unit III: Restoration Planning, Emerging Concepts, and Ethical Considerations

Restoration Planning, Relationship Between Restoration Practice and Restoration Ecology, Local Genetics, Time frame, Performance standards; Societal reasonable amounts of money for projects, Ontogeny, Restoration Ecology as a basis for a new world religion.

Unit IV: Monitoring and Evaluation

Technical and scientific developments; Socioeconomic benefits of ecological restoration; Aims and strategies of restoration: Concepts of restoration, single vs. multiple end-points; ecosystem reconstructions; physical, chemical, biological and biotechnological tools of restoration.; Restoration of biological diversity: Acceleration of ecological succession, reintroduction of biota. Degradation and restoration of natural ecosystems: Forests, grassland. Savanna, aquatic. Restoration of degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration.

SPT- 3.3B: MICROBIAL BIOTECHNOLOGY FOR POLLUTION ABATEMENTS

Course objectives:

The objectives of this course are to sensitize the students to:

- Biotechnological issues- biotechnological interventions in waste treatments and ethical issues.
- Molecular biology- ribosome structure and function; protein biosynthesis in prokaryotes and eukaryotes; post-translational modification; Gene regulation, RNA processing and post transcriptional modifications.
- Eco-friendly techniques- fermentation technology; sericulture technology & biofertilizer technology

Student Learning Outcome

At the end of the course, students should be able to:

- Biochemical technologies for water and wastewater treatment
- Insitu and Ex situ Biormedation
- Bioabsorptin and accumulation of heavymetals
- Microbial interaction in soil water and air

Unit I: Fundamentals of Environmental Microbiology

Introduction – structure and functions of microorganisms, autotrophy and heterotrophy, cultivation of microorganisms. Microbial growth and factors affecting microbial growth. Aero microbiology –sampling techniques, airborne diseases and allergies. Aquatic microbiology –sampling techniques, MPN technique, eutrophication, water borne pathogens and diseases. Soil microbiology – microbes of rhizosphere, microbial role in biogeochemical cycle. Microorganisms of extreme environment. Extremophiles. Role of microbes in environmental pollution and management.

Unit II: Genetically Modified Microorganisms

Genetically modified microbes & their uses in Environmental, Microbial reactors, management of recycling & upgradation technologies, Bioenergy from waste, Biogas technology – process and biogas from organic waste.

Unit III: Environmental Biotechnology

Microbial remediation - composting, bio stimulation, bioaugmentation, bioreactor, bioleaching, bioventing, Biodegradation of xenobiotics. Bioremediation of heavy metals and radio-active wastes. Microbial mediated bioconversion. Role of genetically engineered microbes in pollution control, Biofilms and microbial mats, biofouling, and corrosion.

Unit IV: Biotechnology for Management of Resources

Role of environmental biotechnology in management of resources, Bio-transformation of heavy metals, improved oil recovery, reclamation of wasteland, biomass production, microorganisms in mineral and energy recovery, Insitu and Ex situ Bioremediation, nanotechnology for control of pollution

OEPT- 3.4: CLIMATE CHANGE AND SUSTAINABILITY

Course Objectives:

The objectives of this course are to sensitize the students to:

- Basic and key knowledge of Weather, climate, and Global Climate Change.
- Contribution of Green Houses Gases in Global warming, remedial measures against Global warming and Climate Change and policies.
- Global and National Action Plan related to Climate Change mitigation.

Student Learning Outcome:

At the end of the course, students should be able to:

- Evaluate the role of Remedial Measures in Combating Global Warming and Climate Change.
- Evaluate Various Policies related to Climate Change mitigation Strategies and Create a knowledge base for Global and National initiatives for climate change.
- Understand the benefits of sustainable development and Social Interventions for Sustainable Development.

Unit I: Fundamentals of Climate Change

Atmosphere -Structure and Composition; Weather and Climate; Elements of weather and climate; Factors affecting climate - Natural factors(Continental drift, Variation in the earth's orbit, Plate tectonics, Volcanic activity, Ocean currents)and Anthropogenic factors(Greenhouse Gases, Atmospheric Aerosols, Land use change); Impacts of Climate Change - Higher Temperatures, Changing Landscapes, Wildlife and Ecosystem at Risk, Ocean Acidification, Rising Seas level, Increased Risk of Drought, Fire and Floods, Intensified Storms and Increased Storm Damages, Illness and Disease, Economic Losses, Agriculture Productivity and Food Security; Concepts of global warming potential (GWP); Global Warming and their effects;

Unit II: International Initiatives for Climate Change

Kyoto Protocol; International Carbon Action Partnership; Intergovernmental Panel on Climate Change (IPCC); Global Environment Facility; Paris Agreement; REDD and REDD+; Climate Change Performance Index; National Action Plan on Climate Change (NAPCC); NATCOM; Green building; GRIHA; Climate change scenarios of India: impact of climate change on agriculture, forest, water resources, monsoon system of India.

Unit III: Mitigation Measures

Carbon Sequestration- Biological processes on land (Bio sequestration, Peatland, Forestry, Wetlands, Agriculture, Carbon farming), Chemical processes (Mineral carbonation, Electrochemistry, Chemical scrubbers), Sequestration techniques in Oceans (Seaweed farming, Ocean storage, Ocean fertilisation, Mixing layers, Basalt storage, Acid neutralisation); Carbon Sinks; Carbon Credit - Types of Carbon Credit; carbon Markets; Carbon Offsetting; Carbon Tax; Environmental remediation; Afforestation;

Unit IV: Introduction to Sustainable Development

Definition, scope and elements; Three pillars of sustainable development; Stake holders of sustainable development: People, Government, Investors, Industry, Judiciary & international organizations working for sustainable development.; Developmental Needs of Indian Society: Poverty, unemployment, inadequate housing, unsafe drinking water, deficiency of energy sources and supply, sanitation, unscientific waste management, lack of transportation facilities, unskilled work force and apathy towards political activities.; Social Interventions for Sustainable Development: Education, skill development, people's participation in decision making, women empowerment, inclusive society, human rights, tolerance to diversity, reduction of health inequality, social safety net and Population control.

IV SEMESTER

CPT- 4.1: ENVIRONMENTAL IMPACT ASSESSMENT, POLICIES AND LAWS

Course Objectives:

The objectives of this course are to sensitize the students to:

- Basic principles and characteristics of Environmental impact assessment.
- EIA Procedure including Methodologies of EIA and EIA auditing.
- International and national efforts for environmental protection.

Student Learning Outcome:

At the end of the course, students should be able to:

- Appreciate the philosophies and historical development of EIA in India and elsewhere.
- Demonstrate sound understanding of the EIA process and the methodologies to prepare an EIS.
- Critically examine development actions with the fundamentals understanding of EIA and sustainable development.
- Demonstrate understanding Environmental Laws and policies in India.

Unit I: Environmental Impact Assessment

Definition, Basic Concepts, Origin and Principles of EIA. Nexus between Development and Environment, Need for EIA, Elements of EIA, Environmental Attributes, Nature of Impacts- Primary, Secondary, and Tertiary; Short Term, Long Term, Reversible and Irreversible Impacts. Overview of Impacts, Directly and Indirectly Measurable Impacts of Air, Noise, Water, Land, Biological and Socio-Economic Elements.

Unit II: EIA Procedure

Screening and Scoping in EIA, Methods, Benefits, Legislation of EIA in India and Modification; Role of Statutory Agencies in EIA Clearance; Methodologies of EIA, Checklist, Matrices, Overlays, Cost-Benefit Analysis; Computer Aided EIA; Battelle Environmental Evaluation System - Impact Identification Networks, Strategies for Environmental Management Plan and Green Belt Development Role of Mathematical Models in EIA; Environmental Appraisal of Project with Reference to Industry, Mining and water; Resources projects; Critical Issues and Formulation of Strategies for EMP;

Unit III: Environmental Audit (EA) and Environmental System Management (EMS)

Definition, Concept of EA, Types of EA, Benefits of Environmental Audits, Scope and Objectives, Procedural Requirements of Conducting EA, Preaudit, on-Site Audit and Post Audit Activities, Water Audit, Raw Materials Audit and Energy Audit, Health and Safety Audit. Reuse and Conservation of Water and Energy, Waste Minimization, Environmental and Economic Benefits of an Environmental Audit, Eco-Audit and its Importance in Environmental Management. Concept of ISO 9000 and ISO 14000 series in Environmental System Management.

Unit IV: Environmental Legislation

Issues and problems. International and national efforts for environmental protection. Environmental Policies: Need for policies; Constitutional and Statutory Laws in India, Fundamental Duties and Fundamental Rights, Legal Control of Environmental Pollution with Reference to: Biodiversity Bill, 2006. The Indian Wildlife (Protection) Act, 1972; The Water (Prevention and control of pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Wildlife (Protection) Rules, 1995; The Indian Forest Act, 1927; The Forest (Conservation) Act, 1980; The Forest (Conservation) Rules, 1981;

CPT-4.2: RESEARCH METHODOLOGY, SCIENTIFIC COMMUNICATION, AND ENVIRONMENTAL ENTREPRENEURSHIP

Course Objectives:

The objectives of this course are to sensitize the students to:

- Ability to choose methods appropriate to research aims and objectives
- Skills in qualitative and quantitative data analysis and presentation
- Advanced critical thinking skills

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand of research methodology, including theory of science and qualitative and quantitative methods.
- Skills for critical reading of research literature and for developing a research proposal for a master's thesis project.
- To promote Entrepreneurship as life-skills to improve quality of life, skills of creation and management of entrepreneurial pursuits.
- Competent in planning, conducting, evaluating, and presenting a research project.

Unit I: Introduction

Sampling, data collection and recording. Central tendency: concept, arithmetic mean, mode, median for ungrouped data. Measures of dispersion: relative measures, range, standard deviation, variance, quartile deviation, co-efficient of variability Diagrammatic (Line, bar, pie diagram) and Graphic (Histogram, frequency polygon, frequency curve, cumulative frequency curve)

Unit II: Statistical Methods

Hypothesis testing, significance, and correlation. Correlation: linear models and regressions. Pearson and other correlation coefficients. Multiple regressions, Distribution: Normal, t and chi square test Difference among means: F-test: ANOVA. Principles, design of experiments. Examples of CRD and RBD

Unit III: Research Writing

Overall outline and structure of the article/manuscript. Description, value, and development of points/outlines before writing. Screening of Material for inclusion within the structure of the manuscript. Importance of authors & their sequence, importance of clear title, abstract and summary. Introduction, methods, results and discussions. Writing Style - Active or passive, Punctuation, use of commas, apostrophe, semicolon and colon. Avoiding duplication and repetition. Importance of revisions and references. Plagiarism - paraphrasing and copy write violation. Consequences of plagiarism. Why not to fudge, tinker, fabricate or falsify data. Plagiarism detection tools.

Unit IV: Scientific Communication and Environmental Entrepreneurship

Definition; Need for scientific communication; Importance and use of scientific communication; Public Understanding of Science (PUS), Sources of scientific information – books, scientific reports, scientific journals, magazines, feature syndicates, leaflets, tabloids, wall magazines, seminars, press releases, databases, encyclopaedias on science, etc; Introduction and scope in Bio-entrepreneurship; Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies;

SPT- 4.3A: URBAN ECOLOGY AND SMART CITIES

Course Objectives:

The objectives of this course are to sensitize the students to:

- Concepts and theories of ecology in urban context.
- Principles and strategies for bio-diversity conservation and management for sustainable urban development and the associated conflicts.
- Knowledge on evaluating the environmental and social impacts of urban development and introduce strategies dealing with global challenges of climate change in cities.
- Understand key concepts related to urban ecology (UE) and its intersection with the planning and design disciplines;

Student Learning Outcome:

At the end of the course, students should be able to:

- Understand and discuss how humans are components of urban ecosystems.
- Understand and discuss how urban ecosystems function, the response of plants and animal to urban environments, the ecology of Community interactions in urban systems, and how urban areas affect local, regional, and global biodiversity patterns.
- To raise attention and public awareness of the importance of urban ecosystem management among scientists, policy makers, and general public.

Unit I: Environment in an Urban Setting

Introduction to urbanization; urban sprawl and associated environmental issues. Man, as the driver of urban ecosystem; commoditization of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).

Unit II: Urban Dwelling

Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure, urban settings as loci of sustainability; challenges associated with sustainability and urban future.

Unit III: Introduction of Smart City

Concept of smart city, Objective for smart cities, History of Smart city world and India. Natural spaces in a city, Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs. Examples of urban ecosystems-terrace garden, vertical garden etc. Practice & analysis: Terrace gardening and vertical gardening

Unit IV: Planning and Environmental Management

Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities, management of urban environment; alternative resources; policy and management decisions, Smart cities mission and other government initiatives.

SPT-4.3B: SCIENCE OF CLIMATE CHANGE AND GLOBAL POLICIES

Course Objectives:

The objectives of this course are to sensitize the students to:

- Basic knowledge of Weather, climate, and Global Climate Change.
- Knowledge of contribution of Green Houses Gases in Global warming, remedial measures against Global warming and Climate Change and policies.
- Global and National Action Plan related to Climate Change mitigation.

Student Learning Outcome:

At the end of the course, students should be able to:

- To evaluate the role of Remedial Measures in Combating Global Warming and Climate Change.
- To evaluate contribution of Green Houses Gases in Global warming and thereby bringing Change in Climate.
- To evaluate Various Policies related to Climate Change mitigation Strategies and Create a knowledge base for Global and National initiatives for climate change.

Unit I: Fundamentals of Climate Change

Atmosphere -Structure and Composition; Weather and Climate; Elements of weather and climate; Factors affecting climate - Natural factors(Continental drift, Variation in the earth's orbit, Plate tectonics, Volcanic activity, Ocean currents)and Anthropogenic factors(Greenhouse Gases, Atmospheric Aerosols, Land use change); Impacts of Climate Change - Higher Temperatures, Changing Landscapes, Wildlife and Ecosystem at Risk, Ocean Acidification, Rising Seas level, Increased Risk of Drought, Fire and Floods, Intensified Storms and Increased Storm Damages, Illness and Disease, Economic Losses, Agriculture Productivity and Food Security; Concepts of global warming potential (GWP); Global Warming and their effects; Radiative forcing.

Unit II: International Initiatives for Climate Change

United Nations Conference on the Human Environment - 1972, Stockholm (The Stockholm Declaration, The Action Plan, UNEP); Nairobi Declaration – 1982; Brundtland Report; United Nations Conference on Environment and Development- 1992(Rio Declaration on Environment and Development, Agenda 21 and Forest Principles, CBD, UNFCCC, UNCCD); Rio+5 – 1997; Rio+10 or Earth Summit 2002; Rio+20 – 2012(Green Economy, Institutional Framework for Sustainable Development); Kyoto Protocol; International Carbon Action Partnership; Intergovernmental Panel on Climate Change (IPCC); Global Environment Facility; Paris Agreement; REDD and REDD+; Climate Change Performance Index;

Unit III: India and Climate Change

Climate Change affecting India; India's Efforts to Counter Climate Change; National Action Plan on Climate Change (NAPCC) - National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a "Green India" Goals, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change; NATCOM; Green building; GRIHA; NICRA; BSE-GREENEX; LTEO; NAFCC; India in the international forums on climate change; Climate change scenarios of India: impact of climate change on agriculture, forest, water resources, monsoon system of India; Emission Gap Report.

Unit IV: Mitigation Measures

Carbon Sequestration- Biological processes on land (Bio sequestration, Peatland, Forestry, Wetlands, Agriculture, Carbon farming), Chemical processes (Mineral carbonation, Electrochemistry, Chemical scrubbers), Sequestration techniques in Oceans (Seaweed farming, Ocean storage, Ocean fertilisation, Mixing layers, Basalt storage, Acid neutralisation); Carbon Sinks; The Blue Carbon Initiative; Carbon Credit - Types of Carbon Credit, carbon Markets; Carbon Offsetting; Carbon Tax; Climate engineering - Carbon dioxide removal and Solar geoengineering; Environmental remediation; Afforestation;.

CPPD- 4.4: PROJECT DISSERTATIONS

Course Objectives- Objective of the course is to provide students with a platform to conduct a short hypothesis-based research project.

Student Learning Outcomes- On successful completion of this course, students will be able to understand nuances of, research writing, sampling, and data collection, writing a hypothesis and gaps in research, drawing up appropriate protocols, analytical instrumentation, statistical analysis, writing meaningful inferences, plagiarism free manuscripts and submission research articles.

SKILL BASED VALUE ADDED CERTIFICATE PROGRAMME (Non-Credit)

(Conducted in Association with Industry Partners)

II SEMESTER

OCCUPATIONAL HEALTH AND SAFETY

Course Objectives:

The objectives of this course are to sensitize the students to:

- The maintenance and promotion of workers' health and working capacity;
- The improvement of working environment and work to become conducive to safety and health
- Development of work organizations and working cultures in a direction which supports health and safety at work.
- Promotes a positive social climate and smooth operation and may enhance Work productivity of the undertakings.

Student Learning Outcome:

At the end of the course, students should be able to:

- Ability to anticipate, recognize, evaluate, and control hazardous conditions and practices affecting people, property, and the environment.
- Work individually or on a team to critically analyse, interpret, and provide leadership to address and manage problems in occupational safety and health; and
- Recognize that the practice of occupational safety and health requires ongoing learning, and undertake appropriate activities to address this need.

Duration: Duration: 40 hrs (4 Weeks@ 10 hours/week)

Unit I: Introduction and Scope

Definition of Occupational Health as per WHO/ILO; Occupational Environment- Physical, Chemical, Biological agents; Occupational Health and Environmental Safety Management – Principles practices; Common Occupational diseases: Pneumoconiosis, silicosis, Anthracosis, Byssinosis, Bagassosis, Astertosis, Farmers lung, Lead poisoning, Occupational cancer, Occupational Dermatitis, Radiation hazards.

Unit II: Occupational Hazard and Control Principles

Chemical Hazard: Introduction to chemical hazards, dangerous properties of chemical, dust, gases, fumes, mist, Vapours, Smoke, and aerosols. Route of entry to human system, recognition, evaluation and control of basic hazards, concepts of dose response relationship, bio-chemical action of toxic substances. Concept of threshold, limit values. Occupational hazards of agricultural workers- somatic diseases, accidents, toxic hazards, physical hazards, respiratory diseases, accidents in industry, sickness, absenteeism, health problems associate with different industries.

Unit III: Monitoring for Safety, Health, and Environment

Industrial Hygiene: Definition, Control Methods, Substitution, Changing the process, Local Exhaust Ventilation, Isolation, Wet method, Personal hygiene, housekeeping and maintenance, waste disposal, special control measures. Measures for health protection of workers, preservation of occupational diseases- medical measures, engineering measures, Legislation- The factories Act, 1948. Management Services at the work place.

Unit IV: Occupational Safety, Health, and Environment Management

Occupational Health and Environment Safety Management System, ILO and EPA Standards. Bureau of Indian standards on safety and health 14489 – 1998 and 15001 – 2000, OSHA, Process Safety Management (PSM) as per OSHA, PSM principles, OHSAS – 18001, Performance measurements to determine effectiveness of PSM. Importance of Industrial safety, role of safety department, Safety committee and function, Role and responsibilities of safety officer. Safety Management: Structure, Function, and responsibilities. Concept for training, application of computer, multimedia, communication, The importance of reporting potential health and safety hazards.

EVALUATION PATTERN

Grades

Grades to be awarded (O, A+, A, B+, B, C, P, F) based on following aspects;

1. **Attendance**- minimum 75% attendance to be required for awarding certificates
2. **Continuous assessment**
   a. Assessment at the end of the week -02(Patent application preparation)
   b. Assessment at the end of the week-04 (Identification of non-patentable subject matter)
   c. Assessment at the end of the week-06 (Patent claims design)
   d. Assessment at the end of the week-08(Case studies on patents of India, USA, Europe and WIPO)

***All assessment to be based on submission of assignments.**

3. **Assignments review**: Marks for assignments: Max marks: 50
   a. Novelty + Innovation -10
   b. Plagiarism- 10
   c. Clarity of thought process & organization of the assignment-10
   d. Quality of the references used -10
   e. Writing style, language & bibliography-10

Grades to be awarded

O	Outstanding: (Above 95%)
A+	Excellent: (85-95% % of the allotted Marks)
A	Very Good: (80 -85 % of the allotted Marks)
B+	Good: (70-80 % of the allotted Marks)
B	Above average (60- 70% of the allotted Marks)
C	Average (50-60% of the allotted Marks)
P	Pass (40-50% of the allotted Marks)
F	Fail (Below 40%)

***Average of 4 assignments for award of grades.**

SKILL BASED VALUE ADDED CERTIFICATE PROGRAMME (Non-Credit)

(Conducted in Association with Industry Partners)

III SEMESTER

TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT

Course Objectives:
The objectives of this course are to sensitize the students to:

- Opportunities for alternative sourcing, conservation, efficiency, and repurposing through an understanding of product life cycles from origins to recycling or inevitable disposal.
- Design products, processes, and complex infrastructure systems to promote sustainable attributes of importance to the environment and the global Community.
- Benefits of green fuels with respect to sustainable development.

Student Learning Outcome:
At the end of the course, students should be able to:

- Acquire basic and fundamental concepts of green technologies and green chemistry.
- Understand the processes and products those are safe and hazard free energy technologies.
- Combine technical and scientific skills with an understanding of the environment, renewable energy management, waste utilization, resource management and land-based industries who can contribute to the national and global development.

Duration: Duration: 40 hrs (4 Weeks@ 10 hours/week)

Unit I: Green Technologies:
Definition and concepts: green technology, green energy, green economy, and green chemistry; sustainable consumption of resources; individual and Community level participation, energy conservation; encouraged use of public transport instead of private transport. Successful green technologies: wind turbines, solar panels; 3 R's of green technology: recycle, renew and reduce; paradigm shift from 'cradle to grave' approach. Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies

Unit II: Green chemistry and future
Introduction to green chemistry; principles and recognition of green criteria in chemistry; biodegradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags, green practices to conserve natural resources (organic agriculture, Argo forestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly technologies

Unit III: Application of Green Technology
Green technology in industries, fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources, solar photovoltaic technology Biofuel production (bio-ethanol and biodiesel) Biomass, prevention/ minimization of hazardous/ toxic products, production of biodegradable materials, concept of green building.

Unit IV: Clean Technology for Sustainable Development
Imperatives of clean technology in the context of mitigation and adaptation measures. CDM concept, CDM scenario in India, CDM projects sector-wise, National Action Plan on Climate Change, sustainable habitat, concept of Green architecture. Carbon trading; carbon credits; Carbon sequestration; Carbon Footprint. Issues of Energy security, Food Security and Social security

EVALUATION PATTERN

Grades

Grades to be awarded (O, A+, A, B+, B, C, P, F) based on following aspects;

1. **Attendance**: minimum 75% attendance to be required for awarding certificates
2. **Continuous assessment:**
   a. Assessment at the end of the week -02 (Protocol writing)
   b. Assessment at the end of the week-04 (Informative content preparation)
   c. Assessment at the end of the week-06 (Drawing a clinical trial design)
   d. Assessment at the end of the week-08(Case narration on successful clinical trial)

***All assessment to be based on submission of assignments**

3. **Assignments review: Marks for assignments: Max marks: 50**
   a. Novelty + Innovation- 10
   b. Plagiarism - 10
   c. Clarity of thought process & organization of the assignment-10
   d. Quality of the references used -10
   e. Writing style, language & bibliography-10

Grades to be awarded

O	Outstanding: (Above 95%)
A+	Excellent: (85-95% % of the allotted Marks)
A	Very Good: (80 -85 % of the allotted Marks)
B+	Good: (70-80 % of the allotted Marks)
B	Above average (60- 70% of the allotted Marks)
C	Average (50-60% of the allotted Marks)
P	Pass (40-50% of the allotted Marks)
F	Fail (Below 40%)

***Average of 4 assignments for award of grades**

READING MATERIALS FOR CURRICULLUM

CPT-1.1: ENVIRONMENTAL BIOLOGY AND ECOSYSTEM SERVICES

- An Introduction to Ecology and Environmental Science - Prabu
- Ecology and Environmental Biology-Saha
- Aquatic Ecosystems – Findlay
- Fundamental Ecology – Odum
- Population Ecology – Anupam Pandey
- Introduction to Cultural Ecology - Mark Q. Sutton and E. N. Anderson
- Ecosystem Services: Key Issues - Mark Everard

CPT-1.2: ENVIRONMENTAL CHEMISTRY

- Manahan, S. E. (2017). Fundamentals of Environmental Chemistry, 10th Edition, CRC Press, USA.
- Baird, C. and Cann, M. (2012). Environmental Chemistry, 5th Edition, W.H. Freeman, USA.
- Ahluwalia, V.K, (2017). Advance Environmental Chemistry. Teri Press Publisher
- Connell D. W. (2005). Basic concepts of Environmental Chemistry 2nd Edition, CRC Press, USA.
- Harrison R M (2007). Principles of Environmental Chemistry, RSC Publishing, UK.
- Girard J. (2013). Principles of Environmental Chemistry 2nd Edition, James & Barlett Publishers, USA.
- Hillel, D. (2008). Soil in the Environment: Crucible of Terrestrial Life, 1st edition, Academic Press, USA.
- Lancaster M. (2002). Green Chemistry: An Introductory Text, RSC Publishing, UK.

CPT-1.3 EARTH AND ATMOSPHERIC SCIENCE

- Schwab S.O, Frevert R.K, Edimster T.W and Barns K.K. (1975). Soil and water conservation Engineering, John Wiley and Sons.
- Loehr, R.C. Jesel, W.J. Novak, N.D., Clarkson, W.S. and Friedeman G.S. (1979). Land Application of Wastes (Vol-I and II). Van Nostrand Reinhold Co., New. York.
- Valdia K.S. (1987). Environmental Geology.
- Menard H.W., W.H. Freeman and Company, San Francisco. (1969). The nature of Oceanic life, The Ocean – A Scientific American Book.
- Reed Wicander and James S. Monroe. Essentials of Geology, Wadsworth publishing
- Roy L. Donahue, Raymond W. Miller and John C. Shickluna. (1987). Soils – An Introduction to soils and plant growth V.Ed., Prentice-Hall of India.
- Biswas T.D and Mukherjee S.K. (1987). Text book of Soil Science IV Ed., Mc Graw- Hill.
- Strahler and Strahler. (1970). Environmental Geology, Wiley & Sons, New York.
- Valdiya K.S. (1985). Environmental Geology Allied Publishers New York.

SPT-1.4A ECOTOXICOLOGY

- Introduction to Environmental Toxicology- Landis, W. G. and Yu, M. H. (2003),3rdedition, Lewis Publishers, CRC press, NY
- Essentials of Toxicology – Klaassen, C.D, and Watkins III, J.B. (2003), 3rd Ed., McGrew Hill
- Environmental Impact of Chemicals: Assessment and Control, Quint, M. D., Taylor, D., Purchase, R. (1996), The Royal Society of Chemistry, Cambridge
- Environmental Risk Assessment Reports, Benjamin, S.L. and Belluck, D.A. (2001), CRC Press.
- Casarett and Doull's Essentials of Toxicology. Klaassen, C. and Watkins III, J. B. (2010), 2nd edition, McGraw Hill Education

- Environmental Toxicology-Biological and Health effects of Pollutants. Yu, M.-H., Tsunado, H. and Tsunoda, M. (2011), 3rd edition, CRC Press
- Ecotoxicology, Schuurmann, G. and Market, G. (1998), John Wiley & Sons, Inc.
- Walker CH et al., Principles of Ecotoxicology
- Hoffman, Hand book of Ecotoxicology
- Newman & Clement, Ecotoxicology: a comprehensive treatment

CPT-1.4B: ENERGY RESOURCE MANAGEMENT

- Ristinen R.A. and Kraushaar J.J., Energy and the Environment, John Wiley and Sons, 1998. Energy and the Challenge of Sustainability, World Energy Assessment, UNDP, 2000
- Rai G.D., Non –Conventional Sources of Energy, Khanna Publishers 1997
- Ravingranath N.H., Usha Rao K., B.Nataranjan and P. Monga Renewable Energy andEnvironment-A Policy Analysis for India, Tata- McGraw Hill, 2000
- Nakicenovic N., (ed), Global Energy Perspectives, Cambridge University Press, 1998

II SEMESTER

CPT-2.1: FOREST AND WILDLIFE MANAGEMENT

- Rajendra Maneria, Environment Conservation and Planning.
- Khenshoo, T.N., Environment Concerns and Strategies.
- Tiwari, S.K., 1997. Wildlife Sanctuaries of Madhya Pradesh.
- Khan, T.I., 2000. Global Biodiversity and Environment Conservations. Pointer Publishers, Jaipur.
- Bennett, H.H., 2002. Soil Conservation.
- Deka, M.M., 2002. Joint Forest Management of Water Projects.
- Gangstad, E.O., 2002. Environment Managements of Water Projects.
- Maitra, M.K., 2002. Watershed Management; Project, Planning, Development and Implementation.
- Ural, O., 1980. Soil and Water Conservation.

CPT-2.2 ENVIRONMENTAL POLLUTION AND ITS MANAGEMENT

- Goel, P. K (2006). Water pollution: causes, effects and control. New Age International.
- Gurjar, B. R., Molina, L. T., & Ojha, C. S. P. (Eds.). (2010). Air pollution: health and environmental impacts. CRC press.
- Landrigan, P. J. (2017). Air pollution and health. The Lancet Public Health, 2(1), e4-e5.
- Park, K. (2005). Park's textbook of preventive and social medicine. Preventive Medicine in Obstet, Paediatrics and Geriatrics.
- Pepper, I. L., Gerba, C. P., & Brusseau, M. L. (2011). Environmental and pollution science.
- Purohit, S. S., & Ranjan, R. (2003). Ecology, environment and pollution. Agrobios (India).
- Vesilind, P. A., Peirce, J. J., & Weiner, R. F. (2013). Environmental pollution and control.
- Wang, L.K., Pereira, N.C. and Hung, Y.T. eds., (2005). Advanced air and noise pollution control. Totowa, NJ, USA: Humana Press.

SPT- 2.3A: NATURAL DISASTERS AND RISK ASSESSMENT

- Disaster Management in India, Ministry of Home Affairs, Government of India, New Delhi, 2011
- National Policy on Disaster Management, NDMA, New Delhi, 2009.
- Disaster Management Act. (2005), Ministry of Home Affairs, Government of India, New Delhi, 2005.

- District Disaster Management Plan-Model Template, NIDM, New Delhi, 2005.
- A Global Report - Reducing Disaster Risk, A Challenge for Development; UNDP Publication, 2004.
- Good practices in Community-based disaster risk management; GoI-UNDP Disaster Risk Management Programme; 2002 – 09.
- Alexander, D. Introduction in Confronting Catastrophe, Oxford University Press, 2000
- Chakrabarty, U. K. Industrial Disaster Management and Emergency Response, Asian Books Pvt. Ltd., New Delhi 2007.

CPT-2.3B: SOLID WASTE MANAGEMENT

- Hester, R. E. and R. M. Harrison, (2002). Environmental and health impact of solid waste management activities. Cambridge: The Royal Society of Chemistry.
- Waste Management, IANS (2016), https://swachhindia.ndtv.com/vegetable-markets-get-rs-10-lakh-settingwaste-management-plants-3722/
- Environmental health: ecological perspectives by Kathryn Hilgenkamp
- Understanding Environmental Health: How We Live in the World by Nancy Irwin Maxwell,
- Environmental Epidemiology: Principles and Methods by Ray M.Merrill,
- Radiation and Man – Jain H.C. National Book Trust, New Delhi
- Hazardous wastes and solid wastes / Lie DHF and Liptak B.G (2000), Lewis Publishers, New York

OEPT- 2.4: MAN AND ENVIRONMENT

- Environmental Education – Nanda. A.N. (1996)
- A text book of Environment – Agarwal. K. M. Sikdar. P. K. and Deb. S. C, MacMiller India Ltd., Calcutta (2002)
- Living in the Environment – Principles, Connections and Solutions – Tyler Miller Jr.G, Wadsworth Publishing Co. New York (1996)
- Fundamentals of Ecology 3rd Ed. W.B.Saunders & Co.Philadelphia
- Systems Analysis & Simulation in Ecology Patten B.C. (Ed) 1971 Academic press London
- Population Ecology A Unified study of Animals & Plants Blackwell Oxford, Begon M and Mortimer. M 1981

III SEMESTER

CPT 3.1: CONSERVATION GENETICS

- Biotechnology, Satyanarayana U (2010) Books and allied (P) Ltd., Kolkata
- Cancer Biology, Raymond W.R (2007) Oxford University Press, Newyork
- Essentials of plant Breeding, Phundan Singh, Kalyanai publishers, 2015
- Gene cloning and DNA analysis, T.A. Brown (2010) 6th edition, WileyBlackwell publication
- Human Molecular Genetics, Peter Sudbery (2002) 2nd Edition, Prentice Hall
- Human Molecular Genetics, Tom Strachen and Andrew P. Read (1999) 2nd edition, John Wile and sons.
- Molecular Biotechnology, Principles and application of recombinant DNA Glick and Pasternak. 2010.
- Plant breeding Principles and methods, B.D. Singh 2015, Kalyanai publishers.
- Brown, T. A. 1995. Gene Cloning: An introduction. Chapman and Hall, London

CPT 3.2: GEOSPATIAL TECHNIQUES

- Campbell, J.B.2002: Introduction to Remote Sensing. Taylor Publications

- Fundamentals of Geographic Information Systems, Michael N. Demers: John Wiley and Sons, Inc.
- Fundamentals of Spatial Information Systems, Laurini, R and Thompson, D.: Academic Press London
- Drury, S.A., 1987: Image Interpretation in Geology. Allen and Unwin
- Gupta, R.P.., 1990: Remote Sensing Geology. Springer Verlag
- Ram Mohan Rao. 2002: Geographical Information Systems. Rawat Publication.
- Chang.T.K. 2002: Geographic Information Systems. Tata McGrawHill

SPT- 3.3A: RESTORATION ECOLOGY

- Howell, E.A., J.A. Harrington, and S.B. Glass. Introduction to Restoration Ecology. Island Press, Washington DC. 418 pp.
- Falk, D.A., M.A. Palmer, & J.B. Zedler 2006. Foundations of Restoration Ecology. Island Press, Washington D.C.
- Clewell, A. F., and J. Aronson. 2007. Ecological Restoration: Principles, Values, and Structure of an Emerging Profession. Island Press, Washington, DC.
- Society for Ecological Restoration International Science & Policy Working Group. 2004.
- The SER International Primer on Ecological Restoration. Available on-line for free at:

SPT- 3.3B: MICROBIAL BIOTECHNOLOGY AND ENVIRONMENTAL MANAGEMENT

- Eweis J.B., Ergas S.J., Chang D.P.Y., Schrodwer E.D. (1998.), Bioremediation Principles. New York, Mc Graw Hill.
- Fulekar M.H. (2010), Environmental Microbiology. New York, Taylor & Francis.
- Koukkou A.I. (2011), Microbial Bioremediation of Non-metals:Current Research. Haverhill, UK, Caister Academic Press.
- Lederberg J. (1992), Encyclopedia of Microbiology, New York: Academic Press.
- Maier R.M., Pepper I.L., Gerba C.P. (2006), Environmental Microbiology. San Diego, Elsevier Academic Press.
- Passman F.J. (2003), Fuel and Fuel System Microbiology: Fundamentals, Diagnosis and Contamination Control. West Conshohócken, ASTM International.
- Prescott L.M., Hareley J.P. Klein D.A. (2005), Microbiology (6th Edition). New York, McGraw-Hill Publishing Co. Ltd.
- Sangeetha J, Thangadurai D, David M, Abdullah MA. (2016.), Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Boca Raton, Florida, USA, CRC Press.
- Sen K., Ashbolt N.J. (2011), Environmental Microbiology: Current Technology and Water Applications. Norfolk, UK, Caister Academic Press.

OEPT- 3.4: CLIMATE CHANGE AND SUSTAINABILITY

- The Uninhabitable Earth: Life After Warming - David Wallace-Wells
- This Changes Everything: Capitalism vs. The Climate- Naomi Klein
- The Great Derangement: Climate Change and the Unthinkable- Amitav Ghosh
- Botkin, D.B.Changing the Global Environment, Academic Press, San Diago (1989)
- Frederick K. Lutgens, Edward J. Tarbuck. 1995. The atmosphere: an introduction to meteorology. Prentice Hall publication.
- IPCC. 2006. Guidelines for National Greenhouse gas Inventories. Published by the Institute for Global Environmental Strategies (IGES), Hayama, Japan on behalf of the IPCC.

IV SEMESTER

CPT- 4.1: ENVIRONMENTAL IMPACT ASSESSMENT, POLICIES AND LAWS

- Environmental Impact Assessment: A.K.Shrivastav, APH Publishing Corporation, New Delhi.
- Environmental Impact Assessment: S.A.Abbasi, D.S.Arya,Discovery Publishing House, New Delhi.
- Environmental Pollution Control: Neelima Rajvidya and Dilipkumar Markandey, APH Publishing Corporation, New Delhi. (2005).
- Environment Problems and Solutions: D.K.Asthana and Meera Asthana, S.Chand & Co. Ltd. New Delhi.
- An Introduction to Environmental Management: Dr.Anand S.Bal
- Westman W.E. (1995). Ecology, Impact Assessment and Environmental planning.
- Ulter S.L. (1994). Environmental Risks and hazards, Prentice Hall of India, New Delhi.
- Peter Calow. (1998). Handbook of Environmental Impact Assessment, Mc Graw Hills Inc., New Delhi.

CPT-4.2: RESEARCH METHODOLOGY, SCIENTIFIC COMMUNICATION, AND ENVIRONMENTAL ENTREPRENEURSHIP

- Environmental Statistics (Handbook of Statistics) - Ganapati P. Patil and C. RadhakrishnaRao
- Environmental Statistics - Books LLC
- Scientific Writing: A Reader and Writer's Guide - Lebrun, Jean-Luc
- Scientific Writing - Hall Marian Rose
- Statistics for Environmental Science and Management-Manjunatha
- Wardlaw, A.C. (1985), Practical Statistics for Experimental Biologists. Wiley Chichester.
- Kothari, C.R (1996), Quantitative Techniques, Vikas Publishing Housing Pvt Ltd, Hyderabad
- Miller, J., (1989), Statistics for Advanced Level, Cambridge University Press.

SPT- 4.3A: URBAN ECOLOGY AND SMART CITIES

- D'Monte, Darryl. 1985. Industry versus Environment Temples or Tombs. Three Controversies, Delhi, CSE.
- Ernstson, H. 2011. Re-translating nature in post-apartheid Cape Town: The material semiotics of people and plants at Bottom Road. In: Heeks, R., (Ed.) Conference on "Understanding Development through Actor-Network Theory", London School of Economics, 30 June, London.
- Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science 319: 756-760.
- Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality. Science as Culture 15: 123–138.
- Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
- Richter, M. & Weiland, U. (ed.). 2012. Applied Urban Ecology. Wiley-Blackwell, UK.

SPT-4.3B: SCIENCE OF CLIMATE CHANGE AND GLOBAL POLICIES

- The Uninhabitable Earth: Life After Warming - David Wallace-Wells
- This Changes Everything: Capitalism vs. The Climate- Naomi Klein
- The Great Derangement: Climate Change and the Unthinkable- Amitav Ghosh
- Botkin, D.B.Changing the Global Environment, Academic Press, San Diago (1989)
- Frederick K. Lutgens, Edward J. Tarbuck. 1995. The atmosphere: an introduction to meteorology. Prentice Hall publication.
- IPCC. 2006. Guidelines for National Greenhouse gas Inventories. Published by the Institute for Global Environmental Strategies (IGES), Hayama, Japan on behalf of the IPCC.

- John E. Oliver, John J. Hidore. 2002. Climatology: An AtmosphericScience, Second Edition. Prentice Hall publication.
- John T. Hardy. 2003. Climate Change: Causes, Effects and Solution. John Wiley & Sons publications.
- Manoj Singh. 2012. Climatology: Sonali Publications Publisher

VALUE ADDED COURSE: OCCUPATIONAL HEALTH AND SAFETY

- Fundamental principles of occupational health and safety. Benjamin O. Alli Handbook of Occupational Safety and Health, Louis J. Diberardinis,
- Environmental Hazards: Assessing Risk and Reducing Disaster, Keith Smith, David N. Petley.
- Physical and Biological Hazards of the work place, Peter H. Wald, Gregg M. Stave Proctor and Hughes.,
- Chemical Hazards of the Workplace. Gloria J. Hathaway, Nick H. Proctor, James P. Hughes.,
- Implementation of occupational health legislation at work place, issues and concerns. G. K. Kulakarni.,
- Disaster Management future challenges and OpportUnities by Jagbir Sing, I.K. International.

VALUE ADDED COURSE: TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT

- Baker, S. 2006. Sustainable Development. Routledge Press.
- Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. Green technologies for a more sustainable agriculture (No. 33721). United States Department of Agriculture, Economic Research Service.
- Thangavel, P. & Sridevi, G. 2015. Environmental Sustainability: Role of Green Technologies. Springer Publications.
- Woolley, T. & Kimmins, S. 2002. Green Building Handbook (Volume 1 and 2). Spon Press.
- Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications,2nd Edition, McGraw-Hill, 2000.
- Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Environmental Microbiology, Academic Press, 2000.
- Singh, J.S., Singh, S.P. and Gupta, S.R. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India. 2006.
- Speth, J. C. Global Environmental Challenges – Transitions to a Sustainable World. Orient Longman Pvt. Ltd., New Delhi. 2004.

EVALUATION RUBRICS		
THEORY INTERNAL ASSESSMENT -- 20M		
1. Continuous Theory Internal Assessment C1+ C2+ MCQ (7+3)		
EVALUATION PATTERN: O - Outstanding: (Above 95%) A+ - Excellent: (85-95% % of the allotted Marks) A - Very Good: (80 -85 % of the allotted Marks) B+ - Good: (70-80 % of the allotted Marks) B- Above average (60- 70% of the allotted Marks) C- Average (50-60% of the allotted Marks) P- Pass (40-50% of the allotted Marks) F- Fail (Below 40%)		**10**
2. Assignments (Environmental science) Perspective)		
• Latest developments in that field	**1**	**3**
• Sentence structure and flow	**1**	
• Comparison between the recent technology developments	**1**	
3. Seminars (Journal Club)		
• Concept communication	**1**	**3**
• PPT/Video visibility, clarity & organization	**0.5**	
• References	**0.5**	
• Time limit	**0.5**	
• Confidence in answering queries	**0.5**	
4. Write Up on Innovative Product Production		
• Concept understanding • Technical/scientific supporting material • Objectives	**1**	**4**
• Methodology: Experimental skills and/or mathematical skills/Analytical skills	**1**	
• Innovation Quotient	**1**	
• Reference • Importance/Significance • Grammar and Style	**1**	
PRACTICAL INTERNAL ASSESSMENT -- 10M		
1. Continuous Practical Internal Assessment C1		
EVALUATION PATTERN: Excellent: A (85-100 % of the allotted Marks) Very Good: B (70 -85 % of the allotted Marks) Good: C (55-70 % of the allotted Marks)		**05**

Inadequate: D (< 55 % of the allotted Marks)		
Do Your Own Experiment		
• Selection of the problem	02	05
• Hypothesis		
• Relevant Content		
• Demonstration	02	
• Reporting		
• References	01	
• Grammar/Spelling		
THEORY (INTERNALS AND SEMESTER END EXAMS) 80M		
EVALUATION PATTERN: **Answer in Brief- 2M×10Q=20** **Short Answers – 6M×4Q=24** **Essay Type - 12M×3Q=36**		
Answer in Brief- 2M • Clear definition/description	01	2M×10Q=20
• Importance	0.5	
• Significance	0.5	
Short Answers- 6M • Introduction	01	6M×4Q=24
• Description/classification/pathway/functions etc...	02	
• Diagrams/ Flow charts/tables/charts/representation/general account	02	
• Importance/Significance	01	
Essay Type—12M • Introduction	02	12M×3Q=36
• Description/classification/pathway/functions etc...	04	
• Diagrams/ Flow charts/tables/charts/representation/general account	04	
• Importance/Significance	02	

PRACTICALS (SEMESTER END EXAMS) 40M			
PRACTICALS Major (12) and Minor (08) Experiments-20M			
	Major (12)	**Minor (08)**	
• Understanding of the Objective	01	02	12+8
• Principle of the experiment	04		
• Methods to be followed		03	
• Formula	04		
• Steps of Calculation		02	
• Result	02		
• Conclusion/Inference	01	01	
SPOTTERS --- 10M • Correct Identification	01	02	
• Description	01		
• Significance/Importance			
RECORD SUBMISSION – 03M • CONTENT PAGE		03	
• CERTIFICATE			
• DATES OF EXPERIMENTS			
• CONTENT & LEGIBILITY	01		
• DIAGRAMS /GRAPHS	01		
• PROPER REPRESENTATION OF RESULTS	01		
Case Study—02M			
• Introduction of the of given case and significance	0.5		
• Body of the content and comparison with known and unknown scenario	0.5	2.0	
• Relevance to the content	0.5		
• Conclusion, Reference and recent updated & Supportive materials	0.5		
• Market Perspective			

PRACTICAL VIVA: • Knowledge about the topic • Depth in understanding	02	5.0
• Comprehension	01	
• Clarity in answers • Relating case studies with practical's conducted	02	
GROUP PROJECT		
• Project value • Project innovation and implementation of their ideas • Group coordination and involvement in the activities	20	80
• Plagiarism • Review of Literature • Introduction • Hypothesis • Gaps in Research	20	
• Materials and Methods • Results and Discussion • Summary and Conclusion	30	
• Scientific Knowledge produced • Societal Impact • References • Grammar/ Spelling	10	
PROJECT VIVA- 40M		
• Introduction - Significance of topic, • objectives	10	40
• Review - succinct explanation, current reviews • Methodology -selection of experiments	10	
• Results & Discussion- clear and lucid presentation, organization of data/ charts/ spectral data, highlight of key findings with suitable justification	15	
• Reference- Appropriate references	05	

THEORY QUESTION PAPER PATTERN

Max. Marks = 80 **Time: 03 hours**

1. Answer in Brief (Answer any ten) **02 x 10 = 20**

a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.

2. Write short notes on the following (Answer any four) **04 x 06 = 24**

a.
b.
c.
d.
e.
f.

3. Essay type questions (Answer any three) **03 x 12 = 36**

a.
b.
c.
d.
e.

Note: Equal Weightage should be given to all the units while setting the question paper

PRACTICAL QUESTION PAPER PATTERN

Max. Marks = 40 **Time: 03 hours**

1. Major Experiment:	12 Marks
2. Minor Experiment:	06 Marks
3. Spotters (04):	12 Marks
4. Records:	03 marks
5. Case study:	02 marks
6. Viva –Voce:	05 marks

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