CENTRAL UNIVERSITY OF GUJARAT

SCHOOL OF ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Syllabus for M.Sc. in Environmental Sciences (Semester I - IV)

Credit Based Semester System with effect from the academic year 2023–2024

Syllabus for M. Sc. in Environmental Sciences (Semester I - IV)

Credit Based Semester System

To be implemented from the Academic year 2023-24

1. The duration of the course shall be two academic years and the examination for the M.Sc. degree in Environmental Science will be held in four semesters. The duration of the semesters shall be as follows:

1st Semester - July – December
2nd Semester - January – May
3rd Semester - July – December
4th Semester - January – May

2. The actual credit requirements in the case of a student or a group of students for the Master's degree shall be 72 credits.

3. This course provides an option of Choice Based Credit System (CBCS) for optional papers. The CBCS gives choice for students to select the optional courses from the list of courses provided by SESD, SLS or SCS of CUG or Science Schools/Departments/Centres of any other Institutes/ Universities of National importance.

4. Semester-wise distribution of courses:

Semester	Courses	No. of Courses	Credits
I	Core courses	2	8
	Optional courses	2	8
	Others	1	4
	Total	5	**20**
	Holistic	1	2
II	Core courses	2	8
	Optional courses	2	8
	Others	1	4
	Total	5	**20**
	Extra credits		2
	Holistic	1	2
III	Core courses	4	16
	Optional courses	2	4/4
	Others	1	4
	Total	7	**24**
	Multidisciplinary Course	1	**2**
IV	Others (Project)	1	16
	Term Paper	1	4
	Total	1	20

5. A candidate shall be eligible for appearing at the examination provided he/she prosecutes a regular course of studies in Environmental Science maintaining percentage of attendance as specified by the University.

6. Examinations would be held after the completion of curriculum at the end of each semester. However, evaluation of the practical will be based on continuous assessment as well as on the final Viva-Voce examination of the students on the experiments.

Programme Outcomes (POs)

PO 1	To impart knowledge in the basic and advanced areas to solve practical problems related to environment
PO 2	To enrich the thinking capability of the professionals and to evaluate the interactions among various components of environment
PO 3	To understand the vital connections between the biotic and abiotic components of environment.
PO 4	To enhance the ability to integrate ~~as well as synthesize~~ the acquired knowledge in their fields and beyond to everyday life
PO 5	To benefit the society through entrepreneurial thinking and career-oriented approach in research as well as in industries.
PO 6	To train the students to function effectively as an individual and as a team member or leader in diverse/multidisciplinary areas.

Programme Specific Outcome (PSOs)

PSO 1	To develop understanding of anthropogenic activities and its influence on natural processes.
PSO 2	To educate the young minds to serve the society towards sustainable practices.
PSO 3	To train the students to function as environmental professional to meet recent global challenges
PSO 4	To acquaint the students with the interconnection among watershed, air shed and global climate change
PSO 5	To develop capacity building, problem solver professionals through R & D activities and with job oriented course curricula capable to offer consultancy and extension activities

Course layout of different semester for M.Sc. in Environmental Sciences

Semester – I

CORE COURSES						
Course Code	**Paper No.**	**Paper Name**	**Unit**	**Topic**	**Credits**	**Hours / Week**
ESD 401		Environmental Sciences-An Interdisciplinary Approach	I	Fundamentals of Environmental Sciences	4	4
			II	Environmental Chemistry		
			III	Aquatic and Terrestrial Environment		
			IV	Global environmental issues in present scenario		
ESD 402		Environmental Ecology	I	Fundamentals of Ecology	4	4
			II	Population and Community Ecology		
			III	Bio-Geochemical Cycles & Energy system		
			IV	Industrial Ecology		
OPTIONAL COURSES						
ESD 421		Natural Resources and Sustainable Development	I	Earth Systems and Earth's Processes	4	4
			II	Environmental Resources		
			III	Environmental Geochemistry		
			IV	Sustainable Development		
ESD 422		Environmental Pollution	I	Air Pollution	4	4
			II	Water Pollution		
			III	Soil Pollution		
			IV	Noise and Radioactive pollution		
OTHERS						
ESD 441		Practical Semester I	I	Practical based on ESD401	4	8
			II	Practical based on ESD402		
			III	Practical based on ESD421		
			IV	Practical based on ESD422		
				TOTAL	**20**	**24**
				Holistic Development under NEP 2020	**02**	**02**

Semester – II

CORE COURSES						
Course Code	**Paper No.**	**Paper Name**	**Unit**	**Topic**	**Credits**	**Hours / Week**
ESD 451	1	Biodiversity and conservation	I	Biodiversity Concept	4	4
			II	Biodiversity and Evaluations		
			III	Biodiversity Conservation and Management		
			IV	Biodiversity Conservation and Biodiversity Act		
ESD 452	2	Advanced Instrumentation for environmental application	I	Environmental Monitoring	4	4
			II	Instrumental Method for Analysis		
			III	Instruments for Environmental Analysis		
			IV	Basics in analysis		
OPTIONAL COURSES						
ESD 471	3	Advance Pollution Control Technology	I	Air Pollution Control Technology	4	4
			II	Water Pollution Control Technology		
			III	Soil Pollution Control Technology		
			IV	Advanced Pollution Control Technology		
ESD 472	4	Climate Change and its mitigation Measures	I	Introduction to climate Change	4	4
			II	Climate Change Impact & Risk Assessment		
			III	Technology to Combat Climate change		
			IV	Policy and Mitigation Measures		
OTHERS						
ESD 491	5	Practical Semester II	I	Practical based on ESD451	4	4
			II	Practical based on ESD452		
			III	Practical based on ESD471		
				TOTAL	**20**	**24**
				Holistic Development under NEP 2020	**02**	**02**

*A compulsory 02 credit two to four weeks summer industrial training programme to be undertaken by students.

Semester – III

CORE COURSES						
Course Code	**Paper No.**	**Paper Name**	**Unit**	**Topic**	**Credits**	**Hours / Week**
ESD 501	1	Environmental Biotechnology	I	Environmental Biotechnology: An Introduction	4	4
			II	Remediation Technology		
			III	Waste Treatment		
			IV	Agro biotechnology		
ESD 502	2	Environmental Nanotechnology	I	Environmental nanotechnology: An Introduction	4	4
			II	Nano material Synthesis and Characterization		
			III	Nano remediation Technology		
			IV	Sustainable Nanotechnology		
ESD 503	3	Eco-technology	I	Introduction to Eco-Technology	4	4
			II	Eco technology in cleaner production		
			III	Eco- technological restoration		
			IV	**Biomass Conversion process**		
ESD 504	4	Research Methodology and Statistics	I	Introduction to Research methodology	4	4
			II	Design of experiment		
			III	Environmental Statistics		
			IV	Technical Writing and Communication skills		
OPTIONAL COURSES*						
ESD 521	5	Environment Management	I	Introduction to Environment Management	4	
			II	Environment Management Systems and Life Cycle Assessment		
			III	Environmental Audit and Environmental Economics		
			IV	Environmental laws		
ESD 522	6	Renewable Energy Resources	I	Energy: Renewable & Non Renewable	4	4
			II	Renewable Energy		

			III	Bioenergy		
			IV	Alternative Energy Resources		
ESD 523	7	Occupational Health, Industrial Hygiene and Safety	I	Industrial Hygiene Concept	4	4
			II	Occupational health and Industrial Work Environment		
			III	Operational Control Measures		
			IV	Environmental Safety		
***Any one from ESD521, ESD522 and ESD523**						
ESD 541	4	Practical Semester III	I	Major Practical based on ESD501, ESD502, ESD503	4	8
			II	Minor Practical based on ESD501, ESD502, ESD503		
				TOTAL	**24**	**28**
				Multidisciplinary Course under NEP 2020	**02**	

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Semester – IV

CORE COURSES						
Course Code	**Paper No.**	**Paper Name**	**Unit**	**Topic**	**Credits**	**Hours / Week**
Optional courses						
OTHERS						
ESD 591	1	Project			16	
ESD 592	2	Term Paper			04	
				TOTAL	**20**	

School of Environment and Sustainable Development
Scheme of Courses M.Sc.
M.Sc. in Environmental Sciences

Detail Syllabus for Semester I
CORE COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 401 Environmental Sciences-An Interdisciplinary Approach		
Course Objective: The course is designed to develop the basics of environment, its functioning and interactions that influences the globe positively and negatively. Students from different disciplines of science need the basis to understand the further advanced courses and researches being carried out in this area.		
On completion of the course, the students will be able to:		
Unit-I Fundamentals of Environmental Sciences	LO1	Develop knowledge about the basics of Environmental Sciences, interactions among biotic and abiotic factors of environment and environment in terms of socio-economic benefits.
Unit-II Environmental Chemistry	LO2	The chemistry that binds the different layers of environment through reactions and balancing of chemical molecules.
Unit-III Aquatic and Terrestrial Environment	LO3	Understand characteristics of soil, water and the reactions and functions in nature.
Unit-IV Environmental Biology	LO4	An insight into anthropogenic activities that lead to imbalance in ecosystem natural disasters, and climate change.

ESD401: Environmental Sciences -An Interdisciplinary Approach

Unit I
Fundamentals of Environmental Sciences

Environmental Science: Definition, Principle, Scope, Structure and function of environment. Abiotic and biotic factors: Earth as Eco-system: changes and equilibrium in system. Importance of Environmental Economics. Cost benefits analysis; Use of Natural Resources vis-à-vis sustainability. Strategies for preservation and conversation of environment.

Unit II

Environmental Chemistry

Environmental Chemistry: concept and scope, Stoichiometry, Chemical potential, Chemical equilibria, Acid-Base reactions, Solubility products, Solubility of gases in water, Gas Laws, Classification of elements. Chemical speciation. Atmosphere: Composition, Structure & Heat balance. Particles, Ions and Radicals in atmosphere. Chemical processes for formation of inorganic and organic particulate matter, Chemistry of Air pollutants. Thermochemical and photochemical reactions in the atmosphere.

Thermodynamic Laws: Entropy, Enthalpy and Gibb's energy. Heat transfer process. Mass, Energy, Material transfer and balance.

Unit III

Aquatic and Terrestrial Environment

Aquatic Environment: Characteristics and structure of water bodies. Physio-chemicals and biological parameters. Sources of water contaminants

Terrestrial Environment: Types and formation of soil. Soil Chemistry, Characteristics of soil. Structure and function of soil. Soil Profile – properties. Agrochemicals in the soil. Leachability and permeability of soil.

Unit IV:

Global environmental issues in present scenario

Interaction between Earth, Man and Environment. Case studies on: Toxic Chemical Pollution and Cross-Border Transfer of hazardous waste; Emerging pollutants; Water crisis; Soil fertility; Forest cover changes; Natural and anthropogenic disasters; Urbanisation and Industrialisation; Biodiversity loss; Public health issues; Population and Society

Texts/References:

1. P. D. Sharma; Ecology and Environment; Volume 22 of Popular Biology Text Books Rastogi Publications, 2007
2. Stanley E. Manahan; Fundamentals of Environmental Chemistry; Publisher: CRC Press 1993.
3. M. H. Fulekar; Environmental Biotechnology; Science Publishers, 2010.
4. M. Dayal- Renewable Energy; Environment and Development, Konark Pub.Pvt.Ltd.
5. D.D. Mishra-Fundamental of Environmental Studies, S Chand & Co Ltd (1 December 2010).
6. E.D. Enger, B. E. Smith; Environmental Sciences-A study of Inter relationships, WCB Publication.

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 402 Environmental Ecology		
Course Objective: This courses is designed to develop understanding on the ecological concepts and ecosystem functioning		
On completion of the course, the students will be able to:		
Unit-I Fundamentals of Ecology	LO1	Develop concept of ecology and Ecosystem. Critically acclaimed the interactions between living-non living and living – living component of ecosystem. Acquire knowledge of some basic type of ecosystems.
Unit-II Population and Community Ecology	LO2	Develop knowledge about origin and evaluation of species, Structure of population and establishment of community in ecosystem.
Unit-III Bio-Geochemical Cycles & Energy System	LO3	Understanding of cycling of minerals and content of nutrient at various component of ecosystem. Insight of flow of energy in ecosystem.
Unit-IV Industrial Ecology	LO4	Understand the concept of industrial development in synergy with environment

CORE COURSE
ESD402: Environmental Ecology

Unit I
Fundamentals of Ecology

Ecology: Definition, Principles, Objectives & Scope. Concept of carrying capacity, Assimilative capacity and ecological foot prints. Food chain & Food web. Ecological pyramids. Ecological niche. Keystone species. Ecotypes. Plant Indicators. Ecological Adaptation. Ecological Genetics and Behaviour Ecology.

Eco-System: Concept, Components, Types, Structure, Functions and Stability. Characteristics and Components of Aquatic, Terrestrial and Marine ecosystem. Ecosystems: flow of energy and matter. Coexistence in communities-food webs

Unit II
Population and Community Ecology
Population ecology: Origin of life and Speciation. Population dynamics, interaction and regulation. Life supporting system: Population Genetics, Meta-population, Population density, Structure and function. Ecological succession: Types, trends and models. Concept of climax. Impacts of Invasive species: Ecological, Environmental and Economical.

Community ecology: Origin, evolution, structure, composition and development of community; Ecotone and concept of Edge effect.

Unit III
Bio-Geochemical Cycles & Energy System
Bio-Geochemical Cycles: Gases and sedimentation cycles - Carbon cycle, Nitrogen cycle, Sulphur cycle, Phosphorus cycle and their interaction.

Earth Energy Flow System: Energy Cycles and Energy Budget. Nutrient budgets (terrestrial, aquatic). Green House gasses. Green House Effect. Energy pyramid.

Unit IV
Industrial Ecology
Industrial Ecology: Concept of Industrial Ecology. Eco-product design, Development and Eco labelling. Ecological industrial model. Eco-industrial parks, Industrial symbiosis, Life cycle assessment of Eco-products.

Texts/References:

1. E.P.Odum (1996) Fundamentals of Ecology, Nataraj Publisher. Dehra Dun.
2. K.M.M. Dakshini (1999) Principle and Practices in Plant Ecology, CRC,Boston.
3. M.C.Dash (1994) Fundamentals of Ecology, Tata McGraw Hill. New Delhi.
4. M.C.Mollesh Jr. (1999) Ecology-Concepts and Aplication, McGraw Hill, New Delhi.
5. M.H.Fulekar (2013) Envrionment & Sustainable Development.
6. V.Ingegnoli (2002) Landscape Ecology: a widening foundation, Springer, Bonn.
7. E.J. Kormondi (1999) Concept of Ecology, Prentice Hall of India, New Delhi.
8. Chapman, J.L. and Reiss M.J. (2005) Ecology Principles And Applications, Cambridge University Press, London.
9. E.P.Odum and G.W.Barrett (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd., Singapore.
10. S.V.Rana (2005) Essential of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi.
11. Environment And Ecology-EAS105/EAS 205-R.Radagopalan.

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 421 Natural Resources and Sustainable Development		
Course Objective: To develop analytical skill of sampling procedure for various environmental samples To estimate the pollutants, present in the air, water and soil environment		
On completion of the course, the students will be able to:		
Unit-I Earth Systems and Earth's Processes	LO1	Helps to understand the fundamental concepts of various spheres and their interactions; Catastrophic natural hazards : Prediction and preparedness
Unit-II Environmental Resources	LO2	To know about earth and ocean mineral resources, detail study of different component of Hydrological cycle, and land use Planning
Unit-III Environmental Geochemistry	LO3	Biogeochemical behavior of trace metal. Basic principle of remote sensing and GIS and its application in natural resource management
Unit-IV Sustainable Development	LO4	To understand principles and strategies of Sustainable Development (SD); various SD Models; Sustainable Energy Resources

OPTIONAL COURSE

ESD421: Natural Resources and Sustainable Development

Unit I

Earth Systems and Earth's Processes

Conservation of matter in various geospheres: Fundamental concepts of the five spheres (lithosphere, hydrosphere, atmosphere, biosphere and cryosphere); interactions between the five spheres; Energy budget of the earth. Earth's thermal environment and seasons. , General relationship between landscape, biomes and climate. Climates of India. Indian Monsoon. El Nino. Droughts. Tropical cyclones and Western Disturbances.

Earths processes: concept of residence, time and rates of natural cycles. Catastrophic geological hazards. Weathering; Plate tectonics; floods; landslides; earthquakes; volcanism; avalanche; Prediction and perception of the natural hazards and adjustments to hazardous activities

Unit II

Environmental Resources

*Mineral Resources and Environment***:** Resources and Reserves, Minerals and Population. Oceans as new areas for exploration of mineral resources. Ocean ore and recycling of resources. Environmental impact of exploitation, processing and smelting of minerals.

Water Resources and Environment: Global Water Balance. Ice sheets and fluctuations of sea levels. Origin and composition of seawater. Hydrological cycle. Factors influencing the surface water. Types of water.

Resources of oceans. Ocean pollution by toxic wastes. Human use of surface and groundwaters. Groundwater pollution.

Landuse Planning: The landuse plan. Soil surveys in relation to landuse planning. Methods of site selection and evaluation.

Unit III

Environmental Geochemistry

Environmental Geochemistry: Concept of major, minor, trace and REE. Classification of trace elements. Mobility of trace elements. Geochemical cycles. Biogeochemical factors in environmental health. Human use, Trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land.

Remote sensing: Principle, application in Environmental Sciences. Application of GIS in environment management.

Unit IV

Sustainable Development

Sustainable Development: Principles and Scope of sustainability, Strategies for promoting sustainable development and consumption, Current issues and areas of debate in relation to sustainable development, carrying capacity based planning processes.

Sustainable development control and model: Environmental sustainability, Energy security, Water security, Food security and Social security.

Sustainable Energy Resources: Renewable energy for sustainable development. Natural resources and sustainable development. International efforts for conservation of resources.

Texts/References:

1. M.H. Fulekar, Bhawana Pathak, R K Kale; Environment and Sustainable Development; Springer; 2014.
2. Harikesh N. Misra; Managing Natural Resources: Focus on Land and Water; PHI 2014.
3. Kathy Wilson Peacock; Natural Resources and Sustainable Development.
4. Elizabeth Berner, Robert Berner; Global Enviroment - Water, Air, and Geochemical Cycles, Princeton University Press; 2nd Revised edition edition 2012.
5. Nelson Eby; Principles of Environmental Geochemistry, Brooks/Cole 2003.
6. Elizabeth Berner, Robert Berner; Global Enviroment - Water, Air, and Geochemical Cycles, Princeton University Press; 2nd Revised edition edition 2012.
7. Nelson Eby; Principles of Environmental Geochemistry,Brooks/Cole 2003.

ESD 422 Environmental Pollution This course aims with a variety of perspective on the air pollution, water pollution, soil pollution and noise and radioactive pollution sources. Here in this course we attempt to present why the people are so perturbed by the various types of the pollution problems.		
Course Objective: To understand the basic of air, water, soil, noise and radioactive pollution, their effects on human health, plants, animals, microbes and materials. Meteorology in the dispersion of the air pollutants, various dispersion models and various types of the sampling involved in testing of the pollutants.		
On completion of the course, the students will be able to:		
Unit-I Air Pollution	LO1	Understand the sampling procedures to collect the samples from ambient air and stacks to estimate the pollutants concentrations Understand the hazardous air pollution episodes
Unit-II Water Pollution	LO2	Characterize the physicochemical and biological parameters of the water and wastewater To inspect the contaminated site/treatment facility to assess its status
Unit-III Soil Pollution	LO3	Characterize the physicochemical and biological parameters of the soils Understand the source of the pollutants adversely affecting the properties of the soil Decide the appropriate remediation technology after the assessment of its physicochemical properties
Unit-IV Noise and Radioactive Pollution	LO4	Understand the sources and consequences of the noise and radioactive pollution Remedial strategies to mitigate the noise and radioactive pollution

OPTIONAL COURSE

ESD422: Environmental Pollution

Unit-I

Air Pollution

Air Pollution: Definition. Natural and man-made Air pollution. Types and classification of air pollutants. Transport and diffusion of pollutants. Laws governing behaviour of pollutants in the atmosphere. Effect of air pollutants on human health, plants, animals, microbes and materials. Acid rain. Ozone depletion. Global warming and climate change.

Meteorology of air pollution: Wind speed, direction and their vertical profiles, turbulence, temperature inversion, atmospheric stability classes and characteristic. Heat Island effects and Wind valley effect. Dispersion models.

Sampling of gaseous and particulate pollutants: Ambient air and stack; Elements; sampling systems: active and passive sampling.

Unit-II

Water Pollution

Water Pollution: Definition, Types, Sources and consequences of water pollution. Physico-chemical and microbial characteristics: Domestic, Industrial and Agricultural Wastewater. River Pollution, Marine Pollution and Thermal Pollution. Water Quality Parameters: Criteria and Standards.

Unit-III

Soil Pollution

Soil Pollution: Definition, Sources, Types of soil pollution. Physicochemical and microbial Characteristics of soil pollutants. Soil pollution from Industrial Waste, Domestic Waste, Agricultural Waste and Agrochemical residues. Detrimental effects of soil pollutants. Remedial measures of soil pollution.

Unit-IV

Noise and Radioactive Pollution

Noise pollution: Sources of Noise pollution. Measurement of Noise and Indices. Noise exposure levels and standards. Noise control and abatement measures. Sound pressure level, noise-spectra-octave bands. Combining decibels. Impacts of noise pollution on human health.

Radioactive Waste: Organic and Inorganic. Radioactive exposer to human and environment. Remedial Measures.

Texts/References:

1. Fundamental of Air pollution. 4th Edition, Daniel Vallero, Academic Press, Elsevier . H. Fulekar;.
2. Ambasht R.S.; Environment and Pollution: An Ecological Approach, CBS Publishers & Distributors; 1st Ed. edition 2014.
3. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
4. R.K. Khitoliya; Environmental Pollution, S Chand & Co Ltd; 1st Edn. 2004 edition (1 December 2006).
5. N.Kumar; Air pollution and Environmental Protection-Legislative policies, Mittal Publication.

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 441 Practical Semester I The course is design to provide competency to understand various environmental samples. This course is extension of the theoretical content cover in the courses of ESD401, ESD402, ESD421 and ESD421 for the implementation of practical applicability.		
Course Objective: To develop analytical skill of sampling procedure for various environmental samples To estimate the pollutants, present in the air, water and soil environment		
On completion of the course, the students will be able to:		
Unit-I Practical based on ESD401	LO1	This practical is designed to give practical knowledge of sampling process and analysis of environmental samples. They also learn the survey for assessing the environmental issues in present conditions.
Unit-II Practical based on ESD402	LO2	To obtain practical knowledge to assess ecosystem structure and its productivity. Student will also learn to identify ecological problems associated with industries
Unit-III Practical based on ESD421	LO3	To develop the skill for remediation of soil through physical, chemical and biological methods
Unit-IV Practical based on ESD422	LO4	Estimate the concentration of a pollutant present in the air, water and soil Understand characteristic of Industrial effluent/wastewater for its suitability to reuse/treatment Measuring the Noise pollution level at industrial and residential area

OPTIONAL COURSE

ESD441: Practical Semester –I

Practical based on ESD401

Major:

1. *Estimation of organic carbon and SOM*
2. *Assessment of physico-chemical characters of soil*
3. *Study of biological properties of soil*

Minor

1. Procedure for collection, and preparation Environmental Samples for analysis.
2. Literature survey and documentation on global environmental issues

Practical based on ESD402

Major:

1. Quantitative characterization of plant community.
2. Evaluation of species diversity indices in a given plant community.
3. Determination of Important Value Index (IVI) of trees in Forest Ecosystem.

Minor:

1. Estimation of primary productivity by harvest method.

2. Industrial Ecology survey: Questionnaire/Interview/ Discussion.

Practical based on ESD421

Major:

1. Remote sensing and GIS - Applications of GPS, Image interpretation. Digitization and data generation.
2. Survey for sustainability in rural areas.

Minor

1. Determination of selected elements in mineral and ores.
2. Soil texture analysis.
3. Physicochemical characterization of water samples.

Practical based on ESD422

Major:

1. Estimation of Gaseous pollutant (SOx, NOx, and Ozone) in ambient air.
2. Physicochemical Characterization of Industrial Effluents.

Minor:

1. Determination of particulate matter in (SPM, RSPM) in ambient air.
2. Measurement of Noise level in Industrial and Residential area.

Detail Syllabus for Semester II

CORE COURSE

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 451 Biodiversity and Conservation		
Course Objective: To understand the importance of biodiversity and learn about the various methods and strategies of biodiversity conservation		
On completion of the course, the students will be able to:		
Unit-I Biodiversity Concept	LO1	Understand the values and issues associated with biodiversity
Unit-II Biodiversity and Evaluations	LO2	Understand the national and internal status of biodiversity and need of equity in the use of the benefits of biodiversity and in actions to address biodiversity loss
Unit-III Biodiversity Conservation and Management	LO3	Understand the importance, need and various strategies of biodiversity conservations
Unit-IV Biodiversity Conservation and Biodiversity Act	LO4	Understand convention of biodiversity, provisions under biodiversity Act and various national and international programme on biodiversity

ESD451: Biodiversity and conservation

Unit-I
Biodiversity concept

Biodiversity concept: Definition, Components, Types of diversity: Ecosystem diversity, Species diversity, and Genetic diversity. Alfa, Beta and Gamma diversity. Integrated Biological Indices. Biodiversity values: economical values, food & agriculture, medicine, Industrial material, cultural and aesthetic values, Ecological values. Key stone, Umbrella & Flag ship species, endemic species. Biodiversity issues. Loss of Biodiversity-causes and consequences. Species Extinction.

Unit-II

Biodiversity and Evaluations

Biodiversity status: International/national status. IUCN red list, Threatened Species, Endangered Species, vulnerable species, rare species, extinct species, future prospects. Biodiversity hotspot, India as mega biodiversity hotspot.

Biodiversity provisions: Collective rights, food security, right to land, territories and natural resources, equity, local knowledge, cultural diversity, woman leadership role stop patenting life.

Unit-III

Biodiversity Conservation and Management

Biodiversity Conservation: Importance and need of biodiversity conservation. Strategies for Biodiversity conversation: In-situ National parks, Sanctuaries, Biosphere reserves, N Preservation plots, Sacred groves Ex-situ conservation: Botanical gardens, Zoos, Aquaria, Herbaria. *In vitro* conservation: Germplasm & gene

bank, Tissue culture, Pollen, spore and seed bank, DNA bank. Man and biosphere programme (MAB).

New Conservation strategies: Community reserves, community-oriented approaches, drawing from local values, knowledge and experiences, rendering civil society more responsive, harnessing voluntary action. REDD and REDD+

Unit-IV

Biodiversity Convention and Biodiversity Act

Relevant article on CBD, sharing benefit, biological resources, Biotechnology. Conservation of Eco-System, Sustainable use of biodiversity, transfer of technology, adaption of biodiversity protocols, Bio prospecting.

Biodiversity Act: provisions under biodiversity Act, National and International programme on biodiversity, species management. Biodiversity- IPR, wildlife protection act 1972, Forest Act, International and National policies, Role of WWF, WCU, CITES, TRAFFIC. Role of Government and NGOs. Environmental education and Conservation. State and National Biodiversity Board.

Texts/References:

1. Eric Chivian Aaron Bernstein (2008). Sustaining Life: How Human Health Depends on Biodiversity
2. Shahid Naeem, Daniel E. Bunker, Andy Hector and Michel Loreau (2009) Biodiversity, ecosystem functioning and human wellbeing: An ecological and economic perspective.
3. W.W.Colins and C.O.Qualset (1998) Biodiversity in Agro-ecosystem, *CRC*, Boston.
4. M.H.Fulekar (2010) Environmental Biotechnology, *CRC*.
5. M.H.Fulekar (2005) Environmental Biotechnology, *Oxford & IBH Publishing*, New Delhi.
6. Michael J. Jeffries. (2006). Biodiversity and Conservation. *Routledge*
7. Ahuja, M. R., Ramawat, K.G. (2014). Biotechnology and Biodiversity. *Springer*.

CORE COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 452 Instrumentation & Environmental Statistics In this course the students will learn about the instrumentation techniques applies to environmental samples analysis/monitoring. The statistical contents help the student in validating the data collected		
Course Objective: To understand the basic of air, water, soil, samples collection and various instrumental methods used for environmental monitoring To understand the principle, and working of the various basic and advanced instrument used in the environmental sampling and analysis		
On completion of the course, the students will be able to:		
Unit-I Environmental Monitoring	LO1	Understand the air, water and soil samples collection, processing and analysis Understand basic analytical terminology and various standards preparation for samples analysis.
Unit-II Instrumental Method for Analysis	LO2	Understand the basic of electromagnetic spectrum for instrumentation applications Basic instruments used in the environmental samples analysis
Unit-III Advance Instrumental Methods for Environmental Analysis	LO3	Basic of advanced instrumentation in environmental samples analysis
Unit IV Bioinstrumentation	LO4	To understand the application of instruments to the environmental context.

ESD452: Advanced Instrumentation for Environmental Applications

Unit I

Environmental Monitoring

Environmental sampling: Air, Water, Soil-collection, preservation, storage and analysis of samples.
Methods for analysis of Environmental Samples.
Basic Terminology: Equivalent weight of an acids and bases, Normality, Molarity, Molality, Specific weight, Buffer solution. Precision and accuracy.

Unit-II

Instrumental Methods for Analysis

Fundamentals of basic instruments: Concept, Electromagnetic spectrum, Quantum theory, Beer-lambert law.
Instrumentations: Theory, Principles, Working operation and application of Colourimetry, Flame photometry, Polarimetry,
Spectrophotometry: Atomic Absorption Spectroscopy, Fourier Transform Infra-Red spectroscopy, Gamma Spectroscopy, Liquid chromatography–mass spectrometry, Gas chromatography–Mass Spectrometry, Infra-Red Spectroscopy.

Unit-III

Instruments for Environmental Analysis

Fundamentals of instrumentations: Theory, principles working operation and application of Nuclear Magnetic Resonance, X-RAY Diffraction, *Scanning Electron Microscopy*, Transmission Electron Microscopy.
Chromatography: Gas Chromatography, High performance liquid chromatography, High Performance Thin layer chromatography.

Unit-IV

Bioinstrumentations: Biosensors, Electrophoresis, Gel electrophoresis, Polymerase chain reaction, conventional microscopy, Bioreactors. Green methodology in labs.

Text/References:

1. M.H.Fulekar and Bhawana Pathak (2013). Bioinstrumentation. *I K International publication*, New Delhi,
2. Willard.H., Merritt L., Dean, D.A. and Settle F.A., (1998). Instrumentation Methods of Analysis. 7th Edition, *Wordsworth*, New York.
3. Galen.W. Ewing, (1995). Instrumental Methods of Chemicals Analysis. 5th Edition, *McGraw Hill*, New York.
4. Roger Reeve (2002). Introduction to Environmental Analysis, *John Wiley & Sons Ltd*.
5. D.A.Skoog, D.M. West and F.J.Holler. (2001). Fundamentals of Analytical chemistry, 7th Edition. *Harcourt Asia PTE.Ltd*, New Delhi,
6. APHA standard methods for Water and Wastewater Examination, (1998). 20th Edition, Washington,
7. Kim, Young, Platt, Ulrich. (2008). Advanced Environmental Monitoring. *Springer*
8. Janick Artiola, Ian L. Pepper, Mark L. Brusseau. (2004). Environmental Monitoring and Characterization. *Elsevier*.

Library link, Central University of Gujarat: http://14.139.122.35/drupal/node/19

OPTIONAL COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 471 Advance Pollution Control Technology This course is design to explain the pollutant capturing/ treatment using basic to the advanced pollution controlling technology from the diverse pollution sources in air, water and soil.		
Course Objective: To understand the designing, operation and maintenance of air pollution, water pollution and, soil contaminants treatment technology		
On completion of the course, the students will be able to:		
Unit-I	LO1	Understand the air pollution controlling devices for the capturing/treatment of the pollutants emitted from the stacks and mobile sources
Unit-II	LO2	Understand the strategies and decision making process for the selection of appropriate waste treatment technology Understand preliminary, secondary, tertiary wastewater treatment and chemical process involved in water treatment
Unit-III	LO3	Understand and implementation of the various physical, chemical and biological treatment technology for decontaminate the soil site
Unit-IV	LO4	Understand the Advanced Pollution Control Technology for the treatment of various organic and inorganic pollutants from the contaminated site/samples

ESD471: Advance Pollution Control Technology

Unit I

Air Pollution Control Technology

Abatement of Air Pollution, Control of air pollutants: General methods for control of Gaseous and particulate pollutants- Adsorption, Absorption, Oxidation, Desulphurization, Scrubbers, Condensers, Settling chambers, control equipment for particulate matter-gravity settling chambers, cyclone separator, electrostatic precipitators, Filters: Fabric filters, Bag House filter, Hybrid filters.

Mobile source emission control: Catalytic Convertor. 3-way catalytic convertor. Oxidation catalyst. particle filtration.

Unit II

Water Pollution Control Technology

Wastewater: Nature and constituents, Treatment strategies.

Biological Treatment measures: Dissolved oxygen, suspended solids, nutrient, alkalinity and pH, temperature, micro-organisms. Energy reactions-aerobic and anaerobic conditions. Aerobic: Nitrosobactor, thiobacillus. Anaerobic: Denitrification, phosphorous removal, sulphur reduction.

Preliminary treatment: Unit operation, Screening, Coarse and Grit removal. Primary Treatment: Sedimentation, Equalization Tank, Gravity settling tank, Primary and secondary clarifiers.
Secondary treatment:, biological tower, combined filtration and aeration processes, tapered, step and extended aeration.

Tertiary treatment: Disinfection treatment processes.

Chemical treatment processes: Coagulation, flocculation, chemical oxidation/reduction, and chemical neutralization, ozonisation, chlorination.

Unit-III

Soil Pollution Control Technology

Remedial measures for soil pollution. In situ and ex-situ treatment Technology. Physical/Chemical Treatment Technologies: solidification/stabilization, soil flushing, Chemical oxidation/reduction, electro- kinetic separation, pyrolysis, incineration, plasma pyrolysis. Biological Treatment Technologies: Bioremediation, Phytoremediation.
Bioremediation: Bioventing, Air Sparging, Biosparging, Land treatment. Phyoremediation: Phytoextraction, Phytovolatization, Phytodegradation, Phytotransformation, Rhizosphere bioremediation.

Unit-IV

Advanced Pollution Control Technology

Trickling filters, Rotating biological contactors, Activated sludge technology, Anaerobic digester, Anaerobic contact processes, Fluidized bed reactor, Slurry bioreactor, Sequence batch reactor. Anaerobic sludge blanket reaction, Upflow anaerobic sludge blanket (UASB), Anaerobic baffle reactor, Bioleaching, Heavy metal removal: bio absorption, bioaccumulation, biotransformation.

Texts/References:

1. M.H.Fulekar (2010) Bioremedition technology recent advances, S*pringer*.
2. M.H.Fulekar.(2005) Environmental Biotechnology. *Oxford IBH Publishing Corporation.*
3. N.P.Cheremisinoff (1996) Biotechnology for Waste and Wastewater Treatment, *William Andrew Publishing*, New York.
4. Bruce Rittman, Perry L. McCarty. (2000). Environmental Biotechnology: Principles And Applications, 2nd Edition, *McGraw-Hill*.
5. Raina M. Maierm Ian L. Peppar, Charles P. Gerba. (2000). Envrionmental Microbiology, *Academic Press*,
6. Gabriel Bitton. (1999) Wastewater Microbilogy, 2nd Edition. *Wiley-Liss*.
7. Lawrence K. Wang, Yung-Tse Hung, Nazih K. Shammas. (2009) Handbook of Advanced Industrial and Hazardous Wastes Treatment. *CRC Press*.
8. Lawrence K. Wang, Norman C. Pereira, Yung-Tse Hung. (2005) Advanced Air and Noise Pollution Control. *Springer*.
9. Martin B. Hocking. (2005) Handbook of Chemical Technology and Pollution Control. *Elsevier*.

OPTIONAL COURSE

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 472 Climate Change and its mitigation Measures		
Course Objective: To understand the various natural and anthropogenic impacts affecting climate, its impact on natural resources, various technology through which we can mitigate climate change. This course also includes various national and international policies which have been implemented to curb the climate change.		
On completion of the course, the students will be able to:		
Unit-I Introduction to Eco-Technology	LO1	Understand the climate dynamics, various factor affecting this, processes through which we can quantify.
Unit-II Eco technology in Cleaner Production	LO2	Impact assessment will help to understand the vulnerability of the system, various adaptation measurements. Use of techniques to quantify the changes.
Unit-III Eco-technological Restoration	LO3	Various technology to reduce the CO2 content
Unit-IV Biomass Conversion process	LO4	Understand various national and international policies

ESD472: CLIMATE CHANGE & ITS MITIGATION MEASURE

Credit-4

Unit I: Introduction to climate Change

Climate as a dynamic Earth System, Weather and Climate, Erath's energy Budget, Global Climate overview, Climate variability, Greenhouse gases – short term & long term impact, drivers of Climate change, Emission Scenario-Global and Indian scenario, Heat transport in climate change system, Global and Regional Circulation Pattern, Evolution of climate in geological time scale. Global Warming-key issues relevant to climate change.

Unit II: Climate Change Impact & Risk Assessment

Impacts on Physical Environment: Temparature Rise, Sea level Rise. Impact on: Glacier including Himalayan pattern, Rainfall Pattern, Hydrology and Water resources, Forest, Agricultural and Food Security, Biodiversity, Coastal Zones and Marine Ecosystems, Human Health and other environmental consequences, Concept of Vulnerability. Risk assessment. Climate Change- Adaptation and mitigation.

Unit III: Technology to Combat Climate change

Carbon Sequestration: Carbon Pool, stock, Flux, Sink, Source & Sequestration, Clean Development Mechanism (CDM), REDD, REDD^{++}, Carbon dioxide Capture and Storage (CCS)- Pre-combustion Capture (gasification or reforming), Post-combustion Capture-high pressure membrane filtration, adsorption/desorption processes and cryogenic separation), Oxy-fuel combustion System, Carbon trading, De-carbonization of Carbon dioxide, Reservoir of CO_2- Deep Ocean, Artificial Carbonate Rock. Technology transfer and capacity building, Role of Global Environmental Facility (GEF) in technology transfer.

Unit IV: Policy and Mitigation Measures

International Efforts in combating climate Change: The United Nations Framework Convention on Climate Change (UNFCCC), India's Initial National Communication (NATCOM) to United Nations Framework Convention on Climate Change, United Nation Development Program (UNDP), *Intergovernmental Panel on Climate Change* (*IPCC*), CBD, United Nations Convention to Combat Desertification (UNCCD)**,** Conference of Parties (COP)

India's Perception to Climate Change-India's National Action Plan (Eight Mission), Role of MOEF & other national agencies, UNDP in India addressing climate change, Concept of Adaptation, Factors affecting adaptation strategies. Mitigations Strategies-Policy, Planning, strategies and Program implementation. Climate Change & Sustainable Development

Texts/References:

1. Andrew Dessler, Introduction to Modern Climate Change, 2nd Edition, Cambridge University Press, 2015.
2. Bruce Glavovic, Mick Kelly, Robert Kay, Ailbhe Travers, Climate Change and the Coast: Building Resilient Communities, CRC Press, 2015
3. D. Hartmann, Global Physical Climatology, 1st Edition, Academic Press, 1994
4. **David E. Kitchen,** Global Climate Change: Turning Knowledge into Action, 1st Edition, Prentice Hall, 2013
5. Grégory Beaugrand, Marine Biodiversity, Climatic Variability and Global Change, Earthscan from Routledge, 2012
6. L.Hannah, Climate Change Biology, 2nd Edition, 2014
7. Ryo Fujikura, Tomoyo Toyota, Climate Change Mitigation and International Development Cooperation, Routledge, 2012
8. Wolfson **Richard,** Energy, Environment, and Climate, Second Edition, Norton, 2011

OPTIONAL COURSE

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 491 Practical Semester II		
Course Objective: To understand analytical technique/instruments of air, water, soil, microbial sampling and biodiversity identification used for environmental health assessment		
On completion of the course, the students will be able to:		
Unit-I Practical based on ESD451	LO1	To locate different Biosphere Reserves, Hot spots, Wild life Sanctuaries and Parks of India and identify biodiversity at different scales
Unit-II Practical based on ESD452	LO2	Analysis of different collected Environmental Data
Unit-III Practical based on ESD471	LO3	To develop the skill for remediation of soil through physical, chemical and biological methods
Unit-IV Practical based on ESD472	LO4	Contaminants in workplace environment and assessing the parameters that could affect health of workers and environment.

ESD491: Practical Semester –II

Practical based on ESD451

Major:

1. Indicate Biosphere Reserve, Hot spots, Wildlife Sanctuaries, Parks on map of India.
2. Inventerization of medicinal/ indigenous/ rare/endangered plant species of Gujarat.

Minor:

1. Determination of primary metabolites (protein & carbohydrates) in plant sample.
2. Determination of secondary metabolites (phenol & ascorbic acid) in plant Sample.

Practical based on ESD452

Major:

1. Determination of heavy metals in environment sample by spectrophotometer/AAS.
2. Determination of organic contaminants in environmental sample UV-visible spectrophotometer/HPLC/ Gas chromatography.

Minor:

1. Preparation of acids and alkali of particular material(specify).
2. F-test, t- test and chi square test and correlation of given data set
3. Demonstration of instruments for analysis of environment samples.

Practical based on ESD453

Major:

1. Determination of suspended particulate matter associated pollutants (heavy metals).
2. Estimation of chemical and biological parameter in industrial waste effluent.

Minor:

1. Estimation of coagulant dose/ electrolyte using JAR test.

2. Evaluation of constituents of municipal solid waste (MSW).
3. Estimation of oil and grease from soil/water sample.

Practical based on ESD454

Major:

1. Estimation of air borne contaminants in work place environments.
2. Industrial visit for major hazard control assessment.

Minor:

1. Measurement of noise level at workplace environment.
2. Estimation of light intensity at workplace environment.
3. Risk assessment of selected industry/ commercial complex/ institutions

Detail Syllabus for Semester III

CORE COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 501 Environmental Biotechnology		
Course Objective: To learn the application of biotechnology in protection and restoration of the environmental quality		
On completion of the course, the students will be able to:		
Unit-I Environmental Biotechnology	LO1	Understand the use of biotechnology including genetic engineering to solve environmental problems and issues associated with it
Unit-II Bioremediation	LO2	Understand the role of microorganisms in remediation of contaminated environments
Unit-III Phytoremediation	LO3	Understand the role of plants in remediation of contaminated environments
Unit-IV GMO and Biosafety	LO4	Understand the concerns associated with use of genetically engineered microorganisms

ESD501: ENVIRONMENTAL BIOTECHNOLOGY

UNIT I

Environmental Biotechnology: An Introduction

Environmental Biotechnology: Concept & Historical perspective. Bioprocesses for Cleaner Production. Biotechnological Research and Development. Bioethics, Genetic Engineering: Introduction to Recombinant DNA Technology, Biotechnology to enhance Agricultural Productivity, Public Perception of Biotechnology, Protection of Biotechnology Invention, Intellectual Property Right (IPR), Future of Biotechnology.

UNIT II

Remediation Technology

Bioremediation: Factor influencing Bioremediation, Microbial Metabolism, Enzymatic Degradation, Bio degradative Pathways, Bioremediation: Heavy Metals, Hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAH), Persistent Pollutants, Nuclear Waste Compound, Indigenous Microorganisms, Microbial Sequencing, Development of Phylogenetic Tree, Bioinformatics in Bioremediation, Genomic and metagenomics approaches - Bioremediation.

UNIT III

Phytoremediation: Approaches, Technical considerations, Type of Phytoremediation, Factor Influencing Phytoremediation, Uptake and Translocation, Enzymatic Transformation, Cellular Mechanism for Heavy Metal, Detoxification and Tolerance, Root Exudates, Phytochelatins, Mettalothioneins, Vascular Compartmentalization, Phytoremediation: Novel Transgene Approach, Development of Mycorrhizal Soil, Ecological Remediation.

UNIT IV

GMO and Biosafety:

GMO as an Environmental and Health Issues, Biosafety Protocol, National Biosafety Framework Component, National Biosafety Framework Component - Training and Capacity Building, GMO-Perspectives.

Texts/References:

1. M.H.Fulekar (2010) Bioremediation technology recent advances, springer
2. *Environmental Biotechnology - Theory and Application* – M.H.Fulekar: CRC Press and Science Publisher, USA
3. M.H.Fulekar (2005) Environmental Biotechnology Oxford IBH Publishing cooperation
4. *Bioinformatics – Application in Life & Environmental Sciences* - M.H.Fulekar: Springer Publisher
5. Environmental Biotechnology-Alan Scragg, Oxford University Press.

6. Environmental Biotechnology, A Biosystems Approach, *Author(s): Daniel A. Vallero, PhD,* ISBN: 978-0-12-375089-1, Copyright © 2010 Elsevier
7. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
8. Environmental Biotechnology: Basic Concepts and Applications. 2006, Indu Shekhar Thakur, I. K. International Pvt Ltd.
9. N.P Cheremisinoff (1996) Biotechnology for Waste and Wastewater Treatment, William Andrew Publishing,New York
10. Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Environmental Microbiology, Academic Press, 2000.
11. Gabriel Bitton, Wastewater Microbiology, 2nd Edition. Wiley-Liss; 2nd Edition, 1999

CORE COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 502 Environmental Nanotechnology		
Course Objective: 1. To understand the concept and prospective of Environmental Nanotechnology and 2. To impart theoretical and practical skill to develop nanotechnological application for Environment protection.		
On completion of the course, the students will be able to:		
Unit-I Environmental Nanotechnology: An Introduction	LO1	Learn a broad fundamental knowledge of the concept and prospective of Environmental Nanotechnology and other basic terms related to nanotechnology.
Unit-II Nano Material Synthesis and Characterization	LO2	Understand the various methods of nanomaterials Synthesis (physical, chemical, and biological process) and characterization by advance instruments
Unit-III Nano Remediation Technology	LO3	Understand various process of remediation technology using nano materials.
Unit-IV Sustainable Nanotechnology	LO4	Understand Clean and Green Nanotechnology, life cycle assessment of nanomaterial for sustainable technology.

ESD502: Environmental Nanotechnology

Unit I
Environmental nanotechnology: Introduction

Concept and prospective; research and development; Nano products: nanomaterials, nano devices, energy efficient resources and materials, Nano engineering material for environmental process, operation and control; Environmental clean-up technology approaches and advances.

Nanomaterials: Dendrimers, Nanocomposites, Nano polymers, Nano biopolymers, Nano biofilms, Nano catalyst, Nano semiconductors, carbon nanotubes, Nano clays, Natural nanoparticles.

Unit II: Nano material Synthesis and Characterization

Synthesis of nanomaterials by physical, chemical and biological process: microbial (bacteria, fungi, actinomycetes); plant based nanoparticle synthesis; Nano material - doping and co -doping; Green synthesis of Nanomaterials. Characterization of Nano materials using advance instruments and Interpretation of data.

Unit III: Nano remediation Technology

Nano pollutant: Identification of nano pollutants, characterization of organics and inorganics in air-water-soil environment and ecosystem.
Physic-chemical and biological methods, Nano filtration, microfiltration, ultrafiltration, reverse osmosis, membrane filtration, nanotechnology for water remediation and purification, Nano treatments for industrial waste and waste water

Unit IV: Sustainable Nanotechnology

Industrial ecology concept for nanotechnology, Fate of nanomaterials in environment, life cycle assessment

of nanomaterial, impacts of nanomaterials on health and environment, nanomaterial threats: ecotoxicology, nanomaterial exposure to human and environmental reconnaissance and Surveillance. Clean and Green Nanotechnology, Green Nano electronics, Green Nonmanufacturing, Nano-enhanced energy technologies, Nano enhanced clean up technologies, Nano enhanced green industry technologies, Green nano Policy.

Texts/References:

1. M. H. Fulekar (2010) Nanotechnology Importance and applications, I K international publishing house Pvt.Ltd.

2. Lynn E. Foster: Nanotechnology: Science, Innovation, and Opportunity, December 21, 2005, Prentice Hall

CORE COURSE

Introduction/Pre-requisites for the Course: **ESD 503 Eco-Technology** This course is design based on fundamental knowledge of ecological sciences for the development of sustainable solution and management of the pollution in an energy intensive way. The ecosystem services and the pollution problems which are required for understanding this course have been included in earlier courses.		
Course Objective: To understand the Ecosystem based treatment technology to cleanup the contaminated sites. To understand the ecotechnology based cleaner production process and management of the waste for energy recovery using biomass conversion processes		
On completion of the course, the students will be able to:		
Unit-I	LO1	Understanding the ecotechnology for social welfare and in the management of the agrochemicals
Unit-II	LO2	Understanding the ecotechnology based industrial production process for clean production to minimize the pollution
Unit-III	LO3	Understanding the ecotechnology for the restoration/remediation of the degraded/underutized site
Unit-IV	LO4	Understanding the biomass conversion process for biofuel and valuable product formation

ESD503: Eco-technology

Credit-4

Unit I: Introduction to Eco-Technology

Ecotechnology: Definition, concept and perspective, Eco-designing, Ecotechnology approaches, Ecotechnology for social welfare and sustainable development. Ecotechnology for rural development: Agrochemicals: Synthetic organic chemicals conversion; Factors causing molecular recalcitrance; Molecular structure, Environmental conditions, Microorganism gresencee, Energymetabolism versus cometabolism;
Biopesticides: Concept, Types of Biopesticides, Biopesticides- Control, Regulation of Biopesticides, Biological Pesticides, Formulation, Stabilization, Mode of Action, Advantages and Disadvantages of Microbial Insecticides, Applications, Biochemical Pest Control Agents.
Biofertilizers: Biofertilizer Perspective, Biofertilizers-Types, *Rhizobium*, *Azospirillum*, *Azobacter,* Phosphate Solubilizing Microorganisms, Mycorrhiza, Blue Green Algae, *Azolla*, Compost, Biofertilizer- Potential Use, Biological Nitrogen Fixation.

Unit II: Eco technology in cleaner production

Clean bioprocess technology: History, concept, planning and strategies for urban and rural sustainability. Bioprocesses for cleaner production, sustainable development and economic benefits: Dairy industry production, processes and development, Sericulture Technology, Aquaculture, Honey bee farming, organic farming, Agro eco farming.
Eco-farming: Perspectives, Food sovereignty regarding rural livelihood, smarter food production and yield,
Eco engineering technology. Green Building, Biosenitizer Ecotechnology, Odourless self-flushing bio toilets.

Unit III: Eco- technological restoration

Concept and importance of SPS (Sanitary and Phytosanitary), WTO-SPS agreement, sanitation and Phytosanitation technology: HBPST, TDC, SPS. Green Inhibiter: Environmental green inhibiter.

Eco system dynamics: Restoration of degraded eco system using ecological approach; waste land, mining area, building resilience, Ecological resilience, soil fertility management; water resource management: Rainwater harvesting, Water conservation practices (ancient and modern);

Unit IV: Biomass Conversion process

Biochemical conversion - anaerobic digestion; Types of biogas Plants; Applications – Bioethanol production, Biohydrogen production; Bio-fuel production - Urban waste to energy conversion - Biomass energy programme in India

Composting: Compost, Composting Process, Bio composting: Windrows, Static Pile, In Vessel Method, Challenges and Benefits.

Vermicomposting: Vermicompost, Earthworm Biology, Create Home for Worms, Bedding, Vermicompost Bins, Microorganism Diversity Monitoring / Microbial Assay, Vermicompost Properties,

Texts/References:

1. Patrick C. Kangas (2003). Ecological Engineering:Principles and Practice
2. Howard T. Oduma, and B. Odumb (2003) Concepts and methods of ecological engineering,
3. William J. Mitsch (2012). What is ecological engineering?
4. Bruce E. Rittmann and Perry L. McCarty (2001) Environmental Biotechnology: Principles and Applications
5. K.M.M. Dakshini (1999) Principle and Practices in Plant Ecology, CRC,Boston.
6. M.C.Dash (1994) Fundamentals of Ecology, Tata McGraw Hill. New Delhi.
7. M.C.Mollesh Jr. (1999) Ecology-Concepts and Aplication, McGraw Hill, New Delhi.
8. V.Ingegnoli (2002) Landscape Ecology: a widening foundation, Springer, Bonn.
9. E.J. Kormondi (1999) Concept of Ecology, Prentice Hall of India, New Delhi.
10. Chapman, J.L. and Reiss M.J. (2005) Ecology Principles And Applications, Cambridge University Press, London.
11. E.P.Odum and G.W.Barrett (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd., Singapore.
12. S.V.Rana (2005) Essential of Ecology and Environmental Sciences, Prentice Hall of India, New Delhi.
13. Environment And Ecology-EAS105/EAS 205-R.Radagopalan.

CORE COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 504 Research Methodology and statistics		
Course Objective: On completion of the course, the students will be able to: develop idea about designing a research, understanding the process of performing the research and writing the research results and present them effectively.		
On completion of the course, the students will be able to:		
Unit-I Research methodology	LO1	To understand the basics and types of research and ethics in research.
Unit-II Design of experiment	LO2	The designing of an experiment for research and the requirements to perform it.
Unit-III Technical Writing	LO3	Writing the reports and technical and research papers that help them for publication.
Unit-IV Communication Skills	LO4	Communication forms basis for any interview and also to express the research output and views efficiently.

ESD 504: RESEARCH METHODOLOGY AND STATISTICS

Unit 1 Introduction to Research methodology

Introduction- Concept of research methodology; Research: Meaning, Types, and Characteristics, Positivism and Post positivistic approach to research. Methods of Research: Experimental, Descriptive, Historical, Qualitative and Quantitative methods. Steps of Research. Application of ICT in research

Unit 2 Design of experiment

Planning and designing of experiments, Basic principles of Design of Experiments, uniformity trials, completely randomized, Randomized block and Latin square designs. Research ethics: research integrity, research safety in laboratories, standards and problems in research ethics.

Characteristics of a good design. Basic principles of designs-randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Factorial experiments, (symmetrical as well as asymmetrical); orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment. Completely randomized design, randomized block design and Latin square design.

Unit 3 Environmental Statistics

Sampling, Data collection and recording. Measures of Central tendency – concept; arithmetic mean, mode, median - ungrouped and grouped data. Measures of dispersion-range, standard deviation (grouped and ungrouped data), Variance, Quartile Deviation, Coefficient of variability. Skewness. Kurtosis. Probability, Graphical representation of data. Distribution - normal, binomial and poission. Hypothesis testing, Correlation, Significance of correlation. Linear models and regressions, Multiple Regressions, F-test, t- test and chi square test, ANOVA. Construction and labeling of graphs, histogram, piecharts, scatter plots, semilogarthimic plots. Introduction to statistical software.

Unit 4 Technical Writing and Communication Skills

Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications . Writing of abstracts, summaries, précis, citations etc.; Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proofreading;

Participation in group discussion: presentation of scientific papers. Communication: Meaning, types and characteristics of communication. Effective communication: Verbal and Non-verbal, Inter-Cultural and group communications, Classroom communication. Facing an interview.

References

1. Research methodology: methods and techniques by C R Kothari New Delhi New Age International (P) Limited Publishers 2011Research methodology: vol.I / by Suresh C Sinha and Anil K Dhiman . by Sinha, Suresh C [Author.]. Ess Ess., 2002 New Delhi:Research methods, design, and analysis / Larry B. Christensen, R. Burke Johnson, Lisa Turner. by Johnson, Burke Allyn & Bacon, Boston : 2010
2. Science and ethics / Bernard E. Rollin. by Rollin, Bernard E. Cambridge University Press, Cambridge; New York : 2006
3. Ethics in research by Ian Gregory: London Continuum International Publishing Group 2005
4. Writing and presenting research / Angela Thody. by Thody, Angela. London; Thousand Oaks, Calif.: Sage Publications, 2006
5. Research methods: the basics / Nicholas Walliman. by Walliman, Nicholas. London; New York: Routledge, 2011
6. Research methodology: by Saravanavel,P.: New Delhi: Kitab mahal, 2009
7. Methodology of scientific research programmes: Philosophical papers vol.i / by Imre Lakatos .by Lakatos, Imre [Author.] | Worrall, John [Editor.] | Currie, Gregory [Editor.]. Delhi Cambridge University Press 2001
8. Library link, Central University of Gujarat: http://14.139.122.35/drupal/node/19

OPTIONAL COURSE

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 521 Environment Management		
Course Objective: To develop understanding about various rules and regulations require for environmental managerial position of public and private organizations.		
On completion of the course, the students will be able to:		
Unit-I Introduction to Environment Management	LO1	Understanding of basic concept of environment management and its role in organization.
Unit-II Environment Management Systems and Life Cycle Assessment	LO2	Evolved skill for development of environment management system
Unit-III Environmental Audit and Environmental Economics	LO3	Understand component of environmental audit and economical analysis
Unit-IV Environmental laws	LO4	Understand various environmental laws and its requirement.

ESD521 - ENVIRONMENTAL MANAGEMENT

Credit-4

Unit I: Introduction to Environment Management

Definition, Goals, significance and scope of environmental management, Development and environmental linkages, Environmental concerns in India, Actions for Environmental Protection: Indian initiatives- National committee on Environmental Planning and Coordination, Ministry of Environment, Forest and climate change - Role in Environmental Management, Environmental Management practices.
Environmental Design: Principle, procedure, process, Design consideration, Ecolabelling, Design and certification.

Unit II: Environment Management Systems and Life Cycle Assessment

International Organization for Standardization (ISO), EMS- ISO 14000 series, ISO 14001 – EMS Certification, Environmental Policy, Planning, Implementation and Operation, Checking, Management Review, Benefits of ISO 14001 certification, Origin and development of EIA Environmental Impact Assessment-Definition, Goal, statement, scope and approrach, Purpose and process. Environmental awareness & Public envolvement, Life Cycle Assessment (LCA). Procedure for LCA- Defining goal and scope, Preparation of life cycle inventory, Applications, LCA in relation to sustainable development.

Unit III: Environmental Audit and Environmental Economics

Environmental audit, Types of environmental audits and their objectives. General audit methodology and audit process, basic steps for environmental audit. Element of audit process, audit protocols. Waste audits and pollution prevention assessments, Waste minization audit, Environmental Economics, Valuation of environment impacts: types of economic values, approach, valuation techniques, valuing environmental amenities. Environmental Costs and benefits analysis, cost benefit analysis of technology or process for pollution control.

Unit IV: Environmental laws

Provision of Constitution of India Regarding Environment (Article 48A and 58A). The Environment (Protection) Act, 1986 (Amendment 1991), Water (Prevention and Control of Pollution) Act, 1974 (Amendement 1988), The Air (Prevention and Control of Pollution) Act 1981 (Amendement 1987), Hazardous Wastes (Management and Handling) Rules, 1989, Solid Waste Management and Handling Rules, 2016, Bio-Medical Waste Management Rules, 2016, Forest Conservation Act 1980, Forest (Conservation) Amendment Rules, 2004, Wildlife (Protection) Act 1972 (Amendment 1983, 1986 and 1981).

Texts/References:

1. Environment Management, N. K. Uberoi, Excel Books, Delhi
2. Environment Management, H.V.Jadhav, Vipul Prakashan,Mumbai
3. Environmental Impact Analysis Handbook: J. G. Rau and D. C. Wooten; McGraw-Hill Book Co.
4. ISO 14001: Environmental management systems: Specification with guidance for use (ISO 14001: 1996b (E)). (International organization for standardization – Switzerland).
5. Mohanty. S. K., 2011, Environment and Pollution Law, Universal Law Publishing Co.Pvt. Ltd.
6. Shastri S C, 2008, Environmental Law, (2nd Edn.), Eastern Book Company, Lucknow
7. Singh Gurdip, 2004, Environmental Law in India, Mcmillan& Co.

OPTIONAL COURSE

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 522 Renewable Energy Resources		
Course Objective: To develop understanding of origin, generation process, advantages and limitations of different types of energy resources : Renewable & Non-Renewable, nuclear energy, bio energy etc.		
On completion of the course, the students will be able to:		
Unit-I Energy: Renewable & Non-Renewable	LO1	Helps to understand basics of renewable & non-renewable energy resources, their conservation; Interrelation among socio economic development, environment and energy resources
Unit-II Renewable Energy	LO2	This unit disseminate knowledge regarding origin, advantage & disadvantage of various renewable energy resources like Solar, Wind, Hydro, Geothermal, OTEC etc.
Unit-III Bioenergy	LO3	Develop understanding of various biological sources for energy generation.
Unit-IV Alternative Energy Resources	LO4	Develop concept on Alternative Energy Resources like nuclear energy and advancement in energy sector.

ESD522: Renewable Energy Resources

Credit-4

Unit I: Energy: Renewable & Non Renewable

Energy basics: Conservation of Energy, units, conversion and calorific value; Overview of energy. World scenario, Indian scenario, Energy sources and types of energy and their generation. Renewable & Non-renewable energy. Importance of Coal, Petroleum, Oil and Natural Gas and their environmental prospects. New Energy Resources, Socio-economic development, Energy & Environment, Energy & Development, Future Energy System, Clean Energy Technology.

Unit II: Renewable Energy

Solar Energy: Solar radiations - characteristics & measurements, Introduction to photovoltaics, Solar energy conversion techniques: Solar collectors, Solar Pond. Applications of Solar energy. *Wind Energy:* Origin of wind energy, quantification of wind energy in India, wind energy conversion systems, Wind mill and wind electric generators. Current status and future prospects. *Hydro-Power:* Introduction, hydro-power generation, hydro-power potential in India, Micro, Mini & Mega-power projects, Advantage & disadvantage. *Geothermal Energy:* Introduction and nature of geothermal fields, geothermal energy, Physics of geothermal resources. Technology for exploiting geothermal resources. Potential and prospects in India. *Ocean Energy:* Ocean Energy Resources, Gas Hydrate, Ocean Thermal Energy Conversion (OTEC), *Tidal Energy:* Introduction and principle of tidal power generation, potential and prospects of tidal energy in India.

Unit III: Bioenergy

Energy: Basics, Bi-hydrogen Production methods, Hydrogen production through genetic Engineering, Storage and Transportation, Applications. *Bio-Energy:* Biomass as source, characterization and use as energy sources, Biomass conversion routes: biochemical, chemical and thermochemical. Biomass potential and production in India. *Biogas:* Production, Factors affecting Production, Biogas production techniques: Anaerobic & Aerobic

Types of Biogas Plant, Microbial reactions, Transfer of Technology for Rural Development. *Waste to Energy:* Energy generation from Solid waste, landfills, Sewage & Agricultural Waste, Conversion process and Energy Generation.

Unit IV: Alternative Energy Resources

Nuclear Energy: Introduction, Fusion and Fission, chain reactions, a brief account of nuclear reactors. Energy Plantation: Overview of Energy Plantation, Biodiesel Production and Application. Alcohol fuels – bio-ethanol production using advance technology. Advances in renewable Energy Generation: Processes, Operation, Production technology and Economic benefits. Renewable Energy for Sustainable Development. Energy Management and Auditing. Energy conservation approaches. Economic assessment and sustainable development.

Texts/References:

1. Renewable Energy: Physics, engineering, environmental impacts, economics & planning /by Sorensen, Bent . Publisher: Oxford Elsevier 2011Edition: 4th ed. ISBN: 9789380501574.
2. Non -Conventional Energy Resources. G.D. Rai. Publisher: Khanna Publisher.
3. Biomass to Renewable Energy processes-CRC Press. ISBN: 9781420095173.
4. Energy Technology Vol.2 &3 by Sorensen, Bent. Publisher: London Earthscan Publishing.
5. Environmental impacts of Renewable Energy-/by **Spellman, Frank R**.; **CRC Press;** 2015.

OPTIONAL COURSE

Introduction/Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 523 Occupational Health, Industrial Hygiene and Safety		
Course Objective: The paper provides knowledge about the hazards and risks of human in any given working place. And also, how the processes of industry requires safety in operating condition and surrounding environment is affected.		
On completion of the course, the students will be able to:		
Unit-I Industrial Hygiene Concept	LO1	Introduce the concept of Industrial hygiene; Various physical and chemical hazards in workplace.
Unit-II Occupational and Industrial Work Environment	LO2	Helps to understand various monitoring techniques applicable in industrial work place environment and different notifiable diseases.
Unit-III Operational Control Measures	LO3	The processes in different industries are outlined and the significance at every step of the processing (from raw materials to products).

Unit-IV Environmental Safety	LO4	Auditing in terms of hazards and risks to workers and environment that help to reduce or avoid them.

ESD523: Occupational Health, Industrial Hygiene and Safety

Unit I

Industrial Hygiene - Concept

Introduction: Definition, Scope, Significance and Application of industrial hygiene. Role and function of industrial hygiene. Occupation and Work Place Environment - Recognition, Evaluation/Monitoring and Control. Health problem associated with working environment.

Physical Classification of Air borne contaminants, Physiological classification of chemicals, Toxicity of chemicals, Threshold limit values.

Physical Hazards: Noise, Vibration, Heat and cold stress, Illuminations, ionizing/non-ionizing radiation.
Chemical Hazards: Glass industry, Painting, Metal coating, welding etc.

Unit II

Occupational and Industrial Work Environment

Monitoring of work Environment: Identification and Sources of contaminant. Sampling strategies: Dust, Fumes, Gases, Vapours, Mist etc. Methods of analysis air borne contaminants. Interpretation with the TLV's.

Biological Monitoring: Sampling and analysis of blood, Urine and biological specimens.
Notifiable Diseases: Pneumoconiosis, Silicosis, Asbestosis, Bagassosis, Byssinosis etc.

Unit III

Operational Control Measures

Industrial process/operation, Operation control measure, Plant strategies: siting and layout of chemical plant. Classification and transportation of hazardous chemicals: Storing and handling of hazardous chemicals, Pipeline safety, Use of personal protective equipments.

Respiratory protective equipment and Non-respiratory protective equipments.

Unit IV

Environmental Safety

Major Hazards control system. Chemical process safety. Risk assessment. Hazard and operability studies. Emergency preparation on-site and off-site. Environmental safety audit.

Texts/References:

1) M.H.Fulekar (2006). Industrial Hygiene & Chemical Safety, *I.K. International Publishing Houses*, New Delhi,
2) Allan K. Fleeger, Dean Lillquist, (2006) Industrial Hygiene Reference And Study Guide.
3) M.H.Fulekar: Personal Protective Equipment –Guide to Ports/Dock Workers, *Government of India's Publication*.
4) Barbara A. Plog, Patricia J. Quinlan, (2002) Fundamentals of Industrial Hygiene, National Safety. *Council Press.*

5) Willie Hammer, Dennis Price, (2001). Occupational Safety management and engineering, *Prentice Hall*.
6) C. Ray Asfahl, David W. Rieske (2009) Industrial Safety and Health Management, Prentice Hall,
7) Mark A. Friend, James P. Kohn. (2010) Fundamental of Occupational Safety and Health, *Government Institute*.
8) Micheal S. Bisesi, (2003). Industrial Hygiene Evalution Methods, *CRC Press*.

OPTIONAL COURSE

Introduction / Pre-requisites for the Course: M.Sc. in Environmental Sciences ESD 541 Practical Semester III		
Course Objective: Understand Biological, Nano and Ecological tool based technology in the remediation of various degraded system.		
On completion of the course, the students will be able to:		
Unit-I Major Practical based on ESD501	LO1	Screen the microorganisms and plants tolerant to particular contaminant and determine the concentration of proline and activity of peroxidase in plants
Unit-II Minor Practical based on ESD502	LO2	Students will learn the process/ methods (physical, Chemical, and Biological: (microbial and plant-based) of nano materials Synthesis and characterization of synthesized nanomaterials by advance instruments. Students also learn the Application of nano materials for water purification and nano remediation by different experimental setup
Unit-III Minor Practical based on, ESD503	LO3	Understand the processes in the recovery of energy from the waste materials

ESD551: Practical Semester –III

Practical 501: **Environmental Biotechnology**

1. Screening of microorganisms from contaminated site.
2. Screening of plant species growing at contaminated areas.
3. Estimation of proline and assay of peroxidase activity in plants growing in polluted sites.

Practical 502: **Environmental Nanotechnology**

1. Synthesis of plant based nano-material and Characterization.
2. Microbial synthesis of nano-material and Characterization.
3. Sol gel method of synthesis of nano-material and Characterization.

Practical 503: Renewable Energy

1. Lipids content analysis from different algae
2. Solid waste - Composting
3. Energy generation from waste

Introduction/Pre-requisites for the Course: This course is design based on cutting-edge skill acquired in the during the three semester to solve the environmental issue. The students must take the industrial/societal problem and work intensively for a semester. At the end of this major project, the student make the presentation in front of the evaluation committee and have to submit a dissertation after including the suggestions.
Course Objective: To understand the Ecosystem based treatment technology to cleanup the contaminated sites.

To understand the ecotechnology based cleaner production process and management of the waste for energy recovery using biomass conversion processes		
On completion of the course, the students will be able to:		
Project	LO	Developing skills and capabilities to undertake assigned research project to provide a sustainable solution of critical issues of environmental pollution. During the project work the students are trained to expand the scope of work.

Note: LO- Learning Outcome

Syllabus for Semester IV

OPTIONAL COURSE

ESD591: Project

ESD592: **Term Paper**