

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 2021–2022

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

Credit Based Semester System

To be implemented from the Academic year 2017-2018

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
II	Core courses	2	8
	Optional courses	2	8
	Others	1	4
	Total	5	20
III	Core courses	4	16
	Optional courses	2	4/4
	Others	1	4
	Total	7	24
IV	Others (Project)	1	8
	Total	1	8

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.

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 ESD403		
			IV	Practical based on ESD404		
				TOTAL	20	24

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

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	Instrumentation & Environmental Statistics	I	Environmental Monitoring	4	4
			II	Instrumental Method for Analysis		
			III	Advance Instrumental Methods for Environmental Analysis		
			IV	Environmental Statistics		
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	Occupational Health, Industrial Hygiene and Safety	I	Industrial Hygiene Concept	4	4
			II	Occupational and Industrial Work Environment		
			III	Operational Control Measures		
			IV	Environmental Safety		
OTHERS						
ESD 491	5	Practical Semester II	I	Practical based on ESD451	4	4
			II	Practical based on ESD452		
			III	Practical based on ESD453		
			IV	Practical based on ESD454		
				TOTAL	20	24

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	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		
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	3	Renewable Energy Resources	I	Energy: Renewable & Non Renewable	4	4
			II	Renewable Energy		
			III	Bioenergy		
			IV	Alternative Energy Resources		
ESD 523		Research Methodology	I	Research methodology	4	4
			II	Design of experiment		
			III	Technical Writing		
			IV	Communication Skills		
TOTAL						
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

*Any one from ESD521, ESD522 and ESD523

Semester – IV

CORE COURSES						
Course Code	Paper No.	Paper Name	Unit	Topic	Credits	Hours / Week
Optional courses						
OTHERS						
ESD 591	1	Project			8	16
TOTAL					8	16

School of Environment and Sustainable Development

Scheme of Courses M.Sc.

M.Sc. in Environmental Sciences

Detail Syllabus for Semester I

CORE COURSE

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 conservation 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.

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 Application, McGraw Hill, New Delhi.
5. M.H.Fulekar (2013) Environment & 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.

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 Environment - 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 Environment - Water, Air, and Geochemical Cycles, Princeton University Press; 2nd Revised edition edition 2012.
7. Nelson Eby; Principles of Environmental Geochemistry, Brooks/Cole 2003.

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 exposure 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.

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 (SO_x, NO_x, 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

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 conservation: 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

ESD452: Instrumentation & Environmental Statistics

Unit I

Environmental Monitoring

Environmental monitoring: Concept. 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. Conversion formulas and equations for analytical instrumentations. 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, Spectrophotometry, Flame photometry, polarimetry, Atomic Absorption Spectroscopy, Gas Chromatography, High performance liquid chromatography, High Performance Thin layer chromatography,

Unit-III

Advance Instrumental Methods for Environmental Analysis

Fundamentals of Advance instrumentations: Theory, principles working operation and application of Liquid chromatography–mass spectrometry, Gas chromatography–Mass Spectrometer, Infra-Red Spectroscopy, Fourier Transform Infra-Red spectroscopy, Gamma Spectroscopy, Nuclear Magnetic Resonance, X-RAY Diffraction, Scanning Electron Microscopy, Transmission Electron Microscopy.

Bioinstrumentations: Biosensors, Electrophoresis, Gel electrophoresis, Polymerase chain reaction, conventional microscopy, Bioreactors.

Unit-IV

Environmental Statistics

Basic elements and tools of statistical analysis. 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 poisson. Hypothesis testing, Correlation, Significance of correlation. Linear models and regressions, Multiple Regressions, F-test, t- test and chi square test, ANOVA. Introduction to statistical software.

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*.

OPTIONAL COURSE

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 Converter. 3-way catalytic converter. 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: Nitrosobacter, 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. Phytoremediation: Phytoextraction, Phytovolatilization, 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) Bioremediation technology recent advances, *Springer*.
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). Environmental Microbiology, *Academic Press*,
6. Gabriel Bitton. (1999) Wastewater Microbiology, 2nd Edition. *Wiley-Liss*.
7. Lawrence K. Wang, Yung-Tse Hung, Nazih K. Shamma. (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

ESD472: 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, Electro plating, 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 hazards chemicals: Storing and handling of hazard chemicals, Pipeline safety, Use of personal protective equipment.

Respiratory protective equipment and Non-respiratory protective equipment.

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 Evaluation Methods, *CRC Press*.

OPTIONAL COURSE

ESD491: Practical Semester –II

Practical based on ESD451

Major:

1. Indicate Biosphere Reserve, Hot spots, Wildlife Sanctuaries, Parks on map of India.
2. Inventorization 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

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, Metalllothioneins, 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

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

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 presence, Energy metabolism 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 Inhibitor: Environmental green inhibitor.

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. Odum, 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 Application, 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

ESD504: CLIMATE CHANGE & ITS MITIGATION MEASURE

Credit-4

Unit I: Introduction to climate Change

Climate as a dynamic Earth System, Weather and Climate, Earth'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: Temperature 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 CO₂- 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 Nations 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. Mitigation 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

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 approach, Purpose and process. Environmental awareness & Public involvement, 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 minimization 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 (Amendment 1988), The Air (Prevention and Control of Pollution) Act 1981 (Amendment 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

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.

ESD523: RESEARCH METHODOLOGY

Unit 1 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. 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.

Unit 2 Design of experiment

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. Construction and labeling of graphs, histogram, piecharts, scatter plots, semilogarithmic plots. Completely randomized design, randomized block design and Latin square design.

Unit 3 Technical Writing

Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; 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; Writing of a review article. Application of ICT in research

Data analysis

Unit 4 Communication Skills - Participation in group discussion: Facing an interview; presentation of scientific papers Communication: Meaning, types and characteristics of communication. Effective communication: Verbal and Non-verbal, Inter-Cultural and group communications, Classroom communication.

References

1. Research methodology: methods and techniques by C R Kothari New Delhi New Age International (P) Limited Publishers 2011 Research 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

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

Syllabus for Semester IV

OPTIONAL COURSE

ESD591: Project