CENTRAL UNIVERSITY OF PUNJAB, BATHINDA

M.Sc. (Environmental Sciences and Technology)

Academic Session 2019 – 21

Department of Environmental Sciences and Technology

M.Sc. Program Outcomes:

After completion of the program, the students have:

1. Acquired knowledge and understanding about the environment and various issues and problems associated with it on the local, regional and global level
2. Acquired skills on various environmental monitoring techniques, instruments, pollution control technologies, data analysis and interpretation.
3. Acquired awareness about various policies and legislations
4. Acquired skills and capability to provide solution for the different environmental problems.

SEMESTER I

S.No	Paper Code	Course Title	L	P	Cr	CBCS#
1.	CST.501	Computer applications$	2	-	2	F
2.	EVS.506	Basics in Environmental Sciences/MOOC	4	-	4	F
3.	EVS.507	Ecological Principles	4	-	4	C
4.	EVS.508	Environmental Chemistry	4	-	4	C
5.	EVS. 509	Basic Statistics	2	-	2	F
6.	EVS. 510	EVS- Lab I Ecology (Practical)	-	4	2	C
7.	EVS 541	Seminar I	-	1	1	F
8.	XXX	Interdisciplinary Course*	2	-	2	E
9.	XXX	Value based course#	1	-	1	VB
		Total	19		22	

$ - Offered by Department of Computer Science and Technology

XXX: Interdisciplinary course: Student has to choose the relevant courses offered in other Departments

#Value based courses will be chosen from the list provided by the university

L: Lectures P: Practical Cr: Credits

Mode of transaction: Lecture, demonstration, E-tutoring, case study, co-operative learning, problem solving, power point, e learning

 # Choice based credit system: C- Core courses; F- Foundation courses; E- Elective

SEMESTER II

Sl. No	Paper Code	Course Title	L	P	Cr	CBCS#
1.	EVS.521	Environmental Geosciences	4	-	4	C
2.	EVS.522	Water Pollution and Control Technologies	4	-	4	C
3.	EVS.523	Energy and Environment	4	-	4	C
4.	EVS.524	EVS- Lab III Water and Soil Analysis (Practical)	-	4	2	C
5.	EVS.525	EVS- Lab IV Energy (Practical)	-	4	2	C
6.	EVS.XXX	Elective I (Opt any 1)	4	-	4	E
	EVS 526	Soil Pollution and Management				
	EVS 527	Environmental Nanotechnology				
	EVS 528	Natural Resource Management				
7.	XXX	Interdisciplinary Course	2	-	2	E
8.	XXX	Value based course#	1	-	1	VB
9.	EVS 542	Seminar II	-	1	1	F
10.		Total	19		24	

XXX: Interdisciplinary course: Student has to choose the relevant course from other Departments
#Value based courses will be chosen from the list provided by the university

L: Lectures P: Practical Cr: Credits

Modes of classroom transaction: Lecture cum demonstration, Panel discussion, Seminar, Tutorial, Case study
Tools: PPT, WhatsApp, Video, e-content, google drive
 # Choice based credit system: C- Core courses; F- Foundation courses; E- Elective courses

SEMESTER III

Sl. No	Paper Code	Course Title	L	P	Cr	CBCS#
1	EVS. 551	Principles of Geo-spatial Technology	4	-	4	C
2	EVS.552	Instrumental Methods of Analysis	4	-	4	C
3	EVS.553	EVS- Lab VI Instrumental methods and Geospatial techniques (Practical)	-	4	2	C
4	EVS 560	Industrial Visit/Field Visit and Report Writing		2	1	E
5	EVS XXX	Elective- II (Opt any 1)	4	-	4	E
	EVS 556	Waste Management				

	EVS 557	Ecotoxicology and Occupational Safety				
	EVS 558	Natural hazards and Disaster Management				
	EVS 559	Microbial Technology for Environmental Pollution Abatement				
6	EVS 599	Project I			6	E
		Total	12		21	

L: Lectures P: Practical Cr: Credits

Modes of classroom transaction: Lecture, Demonstration, Lecture cum demonstration, Project Method, Seminar, Group discussion, Field visit, E-tutoring, Dialogue Mode, Collaborative learning, Experimentation, Tutorial, Problem solving, Self-learning, Case study

Tools: PPT, WhatsApp, Video, e-content, google drive

Software tools: ArcGIS, ENVI, Geomatica, Online Tools, Google Earth, Bhuvan

 # Choice based credit system: C- Core courses; F- Foundation courses; E- Elective

Project I Evaluation criteria

- Synopsis presentation
- Quality of presentation
- Subject knowledge and presentation
- Continuous evaluation by the guide

SEMESTER IV

Sl. No	Paper Code	Course Title	L	P	Cr	CBCS
1	EVS. 571	Environmental Impact Assessment and Auditing	4	-	4	C
2	EVS.572	Emerging Trends and Techniques in Environmental Science	4	-	4	C
3	EVS 573	Air & Noise: Pollution and Management	4	-	4	C
4	EVS 574	Re-drafting Environmental Science - I	2	-	2	DEC
5	EVS 575	Re-drafting Environmental Science - II	2	-	2	DEC
6	EVS 576	EVS- Lab V Air & Noise pollution (Practical)	-	4	2	C
7	EVS.599	Project II	-	6	6	E
		Total	16		24	

L: Lectures T: Tutorial P: Practical Cr: Credits

Mode of transaction: Lecture, Power point presentation, Seminar, Practical demonstration/Experiments, Field visit, Case Study, group discussion and project

 # Choice based credit system: C- Core courses; F- Foundation courses; E- Elective courses

Project II - Evaluation criteria

- Relevance, need and clarity in the objectives
- The originality and quality of the content
- Quality of presentation
- Subject knowledge and presentation viva
- Time line of completion of project
- Continuous evaluation by the guide

SEMESTER- I

Course Code: CST.501
Course Title: Computer Applications

L	T	P	Cr
2	0	0	2

Course Objectives: The objective of the course is to provide the student a basic knowledge about the computers and their components both hardware and software. The course will introduce and provide a hands-on training on MS office, paint, spread sheets, notepad, endnote and internet browsing. The course will help the students in performing various calculations in research to present the results in a more meaningful manner.

Unit 1 **7 Hours**

Fundamentals of Computers: Block Diagram of Computer, Hardware Components, Introduction to computer network and World Wide Web.

Unit 2 **7 Hours**

Sharing Data over Network, Computer Configuration, Memory Hierarchy, Software Structure. Introduction to MS Paint, Notepad and Word.

Unit 3 **8 Hours**

Introduction to Word Processing and Microsoft Office, Creating and Saving Documents, Text Formatting, Tables, Document Review Option, Mail Merge, Inserting Table of Contents, Reference Management.

Unit 4 **8 Hours**

Spreadsheet applications, Presentation applications, Internet browsers and Image processing applications.

Course outcome:

At the end of this course, the student will be able to

- Apply different computer tools
- Analyze the data collected during their practical and project work

Suggested Readings

1. Harvey, G. MS Excel for Dummies. John Wiley & Sons Inc
2. Sinha, P.K. (2004). Computer Fundamentals, BPB Publications

3. Bhatt, Pramod Chandra P. (2008). An introduction to Operating systems: Concept and practice. 2nd Edition, PHI learning Pvt. Ltd, New Delhi.

Course Code: EVS 506
Course Title: Basics in Environmental Sciences

L	T	P	Cr
4	0	0	4

Course Objectives: The objective of the course is to acquaint the student with a basic understanding of the concept and structure of environment. The course will help the student to develop and understanding about the significance of the development of environmental science as a discipline. The global environmental issues and disasters will also be introduced to the students through the course.

Unit 1: Introduction **15 Hours**

Connecting to the issue of environment; ecology of environment; components of environment and their interactions; human-environment interface, relationship dynamics and resource conflicts. Environmental Science – definition, principles and scope, multidisciplinary approach – chemistry, physics, biology, mathematics. Environmental ethics and role of education in solving environmental issues.

Unit 2: Structure of the Environment **15 Hours**

Atmosphere, Hydrosphere, Lithosphere and Biosphere - Definition, Structure and composition; Structure of Environment

Unit 3: Global Environmental Issues **15 Hours**

Green House Effect - Greenhouse gases its sources, impacts, consequences and remedial measures; global warming. Global Climate change, World and Indian scenario, Acid Rain; Brown Haze, Photochemical smog, nuclear winter; Ozone depletion.

Unit 4: Environmental disasters **15 Hours**

Bhopal gas tragedy, Fukushima and Chernobyl disaster, Love Canal tragedy, Minimata Accident, Creation of UNEP and its role, World earth summits; Agenda 21, UNFCCC, Convention on Biodiversity and Convention on Climate Change, CoPs, Climate Change and Global Warming; IPCC and its reports

Course outcomes:

At the end of this course, the student could

- Define environment and describe the structure and significance of the spheres of the environment
- Describe the important environmental issues and the factors responsible for their cause
- Understand the significance of environmental science as a subject

Suggested Readings:

1. Cunningham W.P, Cunningham M.A, (2007). Principles of Environmental Science, Inquiry and application. McGraw Hills Education.
2. Chiras D.D, (2010). Environmental Science, 8th ed. Janes & Bartlett Publishers.
3. Dave D, 2012. Environmental Studies, Publisher, CENGAGE learning.
4. Cunningham W.P, Cunningham M.A, (2015). Environmental Science – A global concern, 13th edition. McGraw Hills Education Publisher.
5. Prasad and Govid (2002). Conservation of natural Resources, Discovery Publishing, New Delhi.

L	T	P	Cr
4	0	0	4

Course Code: EVS 507
Course Title: Ecological Principles

Course Objectives: The objective of the course is to acquaint the students with basic knowledge of the biological organisms, their population, communities and their living environment. The course will also provide the understanding of the principles of ecology and biodiversity and the various threats disturbing them.

Unit 1: Introduction to Ecology **15 Hours**

Definition, principle and scope of ecology, major branches, history, origin and evolution of life, geological scale. Habitat and niche, adaptation, ecosystem, biotic and abiotic factors, food chain, food web, trophic level. Biogeography – classification and zones

Unit 2: Ecosystem Dynamics **15 Hours**

Concept and components of ecosystem, ecological pyramids, energy flows in different ecosystems, energy models, ecosystem productivity. Types and characteristics of ecosystem- terrestrial (forest, desert, grassland) and aquatic (pond, marine), wetlands, estuaries, natural and man-made ecosystems, forest types in India. Biogeochemical cycles – cycling of water, nutrients.

Unit 3: Population and Community Ecology **15 Hours**

Population characteristics, population interaction; prey-predator relationships, competition, exploitation, mutualism, Theories of population growth, population dynamics, regulation. Concept of metapopulation, demes and dispersal, niche- concept and types, keystone species, Flagship species and umbrella species; dominant species, ecotone, edge effect, ecotypes, plant indicators; ecological succession – types and mechanism, Theory of Island Biogeography, abundance and distribution of species; factors leading to commonness, rarity and vulnerability of extinction of species.Green data book.

Unit 4: Biodiversity **15 Hours**

Definition, levels of biodiversity, measurements of biodiversity, values of biodiversity. Hot spots of biodiversity, Biodiversity hotspots of India, threats

to biodiversity. Biological Invasion: concept; pathways, process, mechanism, impacts, examples of major invasive species in India. Speciation- types and process, Causes of species extinction. Endangered and threatened species, IUCN Categories of threatened species, Red data book, List of threatened flora and fauna in India. Biodiversity conservation; Ecotourism, responsible tourism, role of inter-governmental, government and non-government organizations, legal initiatives for wildlife and forest conservation, wetland conservation, ecosystem management at national and international level; Convention on Biodiversity.

Course outcomes:
At the end of this course, the student will be able to:

- Define and describe ecosystem and their types
- Explain the ecological processes and their interaction with the environment
- Explain biodiversity, its threats and conservation methods

Suggested Readings:

1. Eugene P. Odum and Gary W. Barrett. (2018).Fundamentals of Ecology, 5e. Cengage Learning.
2. Begon, M, Howrath, R.B. and Townsend, C.R. (2014). Essentials of Ecology, 4th Edition.John Wiley & Sons, Inc.
3. Larry L.Rockwood. (2015). Introduction to Population Ecology, Second Edition. John Wiley & Sons, Inc. and Blackwell
4. Peter J. Morin. (2011). Community Ecology, Second Edition. John Wiley & Sons, Inc. and Blackwell
5. Richard B. Primack. (2014).Essentials of Conservation Biology, Sixth Edition. Sinauer Associates, Inc.

Course Code: EVS 508
Course Title: Environmental Chemistry

L	T	P	Cr
4	0	0	4

Course objectives: The objective of the course is to acquaint the student about the chemical composition of the different matrices of the environment (air, water, soil) and the interaction involved between them.

Unit 1: Chemistry for Environment **15 Hours**

Fundamental of environmental chemistry: Mole Concept, Solution chemistry, solubility product, Solubility of gases, Phase change thermodynamics, Electrochemistry and redox reactions, Gibbs' free energy; Chemical potential; Activity and fugacity, Chemical kinetics and chemical equilibrium.

Sources of natural and artificial radiations: Dosimetry, types of dosimeters, radioactive substances, applications and handling of isotopes and other radionuclides in environment.

Unit 2: Air & Water Chemistry **15 Hours**

Atmospheric chemistry: Composition of air, Chemical speciation, particles, ion and radicals, Formation of particulate matter, Photochemical reactions

in the atmosphere, Chemistry of air pollutants, Photochemical smog, Acid rain, Ozone chemistry, Greenhouse gases and Global warming, Thermal Pollution.

Aquatic chemistry: Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, carbonates, redox potential, Pourbiax diagram.

Unit 3: Soil and Geochemistry **15 Hours**

Chemistry of Soil: Physio-chemical composition of soil, humus, Inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, Cation exchange capacity (CEC), Reactions in soil solution, Ion exchange (Physiosorption), Ligand exchange (Chemisorption), Complexations, Chelation; Precipitation / dissolution.

Environmental geochemistry: Concept of major, trace and REE. Classification of trace elements, Mobility of trace elements, Geochemical cycles. Biochemical aspects of Arsenic, Cadmium, Lead, Mercury, Carbon monoxide, O_3, PAN, MIC and other carcinogens

Unit 4: Green Chemistry **15 Hours**

Green chemistry and green technology: New trends in green chemistry, Basic principles, Atom economy concept and its environmental importance, Green reagents, Green solvents, Green technology: Microwave heating & pollution, Ultrasound technique, Industrial Ecology.

Course outcomes:

At the end of the course, the student will be able to

- explain the chemical nature and interaction of the air, water and soil
- Apply analytical tools to determine and measure pollutants in various environmental samples.

Suggested readings:

1. Stanley Manahan and Stanley E. Manahan. (2009).Environmental Chemistry, Ninth Edition. CRC Press
2. Subramanian, V, (2011). A Text Book Environmental Chemistry. International Publishing House.
3. Ahluwalia, V.K, (2017). Advance Environmental Chemistry. Teri Press Publisher.
4. Weiner E.R, (2013). Application of Environmental Aquatic Chemistry: A practical guide. CRC Press Taylor & Francis Group.
5. Connell D.W, (2005). Basic Concept of Environmental Chemistry. Publisher: CRC Press.

Course Code: EVS.509
Course Title: Basic Statistics

L	T	P	Cr
2	0	0	2

Course Objectives: The course is designed to familiarize the students with statistical tools and techniques for the analysis of environmental data. The

course will educate the student to extract information from data, art to analyze and represent data in a scientifically presentable form.

Unit 1 **8 Hours**

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart.

Unit 2 **8 Hours**

Measures of central tendency- mean, mode and median; dispersion (including box and whisker plot), skewness and kurtosis. Sampling and Study Design

Unit 3 **8 Hours**

Random experiments, Probability, combinatorial problems, conditional probability, Binomial Distribution.

Unit 4 **6 Hours**

Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots; curve fitting; Hypothesis testing, t-test, z-test, x2 test.

Course outcomes:

At the end of this course the student will be able to

- Apply the statistics as a tool to interpret the data
- Design an experiment for R&D purpose

Suggested Readings

1. Murray R. Spiegel and Larry Stephens (1999). Schaum Outline of Statistics. McGraw-Hill Education (ISE Editions)
2. Richard A. Johnson, Gouri K. Bhattacharyya (2016). Statistics Principles and Methods, Wiley
3. Robert V. Hogg, Joseph Mckean, Allen T. Craig (2014). Introduction to Mathematical Statistics, Pearson
4. B.L. Agarwal (2013). Basic Statistics, New Age International Limited
5. George Argyrous (2011). Statistics for Research, SAGE.

Course Code: EVS.510
Course Title: EVS Lab I Ecology (Practical)

L	T	P	Cr
0	0	4	2

Course objectives: The students will be trained in designing the scientific methods/experiments to study various ecological parameters and biodiversity in laboratory/field conditions.

1. To study and enlist various biotic and abiotic components of pond and forest ecosystem.

2. To determine minimum quadrat size for studying vegetation in a grassland.
3. To calculate density, frequency and abundance of plant species in grassland using quadrat method.
4. To determine basal area and dominance of species.
5. To calculate Importance value index (IVI) of species.
6. To calculate index of diversity, richness, evenness and dominance of species
7. To study ecology of some more exotic invasive weeds.
8. To estimate chlorophyll content of plant leaves.
9. To study percent cellular respiration.
10. To estimate carbohydrate content in given plant sample.
11. To estimate protein content in the given sample.

Course outcomes:

The student will be able to analyze the ecological conditions or parameters in the field

SEMESTER- II

Course Code: EVS.521
Course Title: Environmental Geosciences

L	T	P	Cr
4	0	0	4

Course Objectives

- To understand on formation of earth and different earth processes
- To understand the meteorological parameters and its effect on earth
- To learn about climate, its circulations and classification
- To understand mechanisms involved in oceanic circulations, marine resources and its pollution

Unit 1: Earth processes **15 Hours**

Structure and Composition of the Earth; Plate tectonics; Formation of oceans and landmasses; Mountain Building; Mass Movements; Vulcanicity; Seismicity; Formation of lakes, rivers and streams; Wind; Glacial processes; Weathering and Erosion; Mass movement; Geological Time Scale.

Unit 2: Meteorology **15 Hours**

Fundamentals of meteorology, Scales of meteorology, Parameters of meteorology- pressure, wind, Rotation of earth- Coriolis acceleration, angular momentum; temperature, humidity, radiation; Radiation Budget of Earth; Topographic effects.

Unit 3: Climatology **15 Hours**

The boundary layer; Local microclimate; Atmospheric movements; General meridional circulations: Hadley cells; Middle latitudes; Circulation of water and energy in atmosphere; Weather, and Climate in India; Seasons and monsoons; Climatic classification schemes; Biogeographical regions of the world; Impact on sea level in south Asian region.

Unit 4: Oceanography **15 Hours**

Sea water properties; Chemistry of seawater; Wind driven circulations in upper oceans; Waves, Tides and Currents; Upwelling and El Nino; Deep Ocean Circulations; Marine Resources; Marine flora and fauna- Benthic and Pelagic Communities; Marine Pollution; Ocean warming, Sea level rise

Course Outcomes

- Students will be able to explain the processes involved in earth formation, meteorological parameters, climatic system and ocean.

Suggested readings:

1. Theobald Lane (2017). Essentials of Oceanography, Larsen & Keller
2. Frederick K. Lutgens, Edward J. Tarbuck, Dennis Tasa (2015). The Atmosphere: An Introduction to Meteorology , Pearson
3. Steven A. Ackerman, John A. Knox (2012). Meteorology: Understanding the Atmosphere, Jones & Bartlett Learning Publication
4. Mark Denny (2011). An Introduction to Oceanography, Overseas Press
5. John M. Wallace, Peter V. Hobbs (2006). Atmospheric Science: An Introductory Survey, Academic Press, Elsevier.

Course Code: EVS 522
Course Title: Water Pollution and Control Technologies

L	T	P	Cr
4	0	0	4

Course Objectives

- To learn about various drinking water sources, purification techniques and standards of potable water
- To understand different types of water pollution and its consequences
- To characterize water and wastewater
- To understand generation and treatment techniques of waste water with special focus on biological treatment
- To learn about the sludge, its scope and treatment steps

Unit 1: Drinking Water Characteristics and Purification Techniques **14 Hours**

Water Sources – Availability & quality of Surface water and Ground water; Water Requirements for Domestic Consumption (Population forecasting); Water Treatment process – Principal, process design and applications (Collection & pumping, Aeration, flocculation, Sedimentation, Filtration, Disinfections (Chlorination, UV, Ozonization), water softening Drinking water standards (physical, chemical & bacteriological)

Unit 2: Water pollution **15 Hours**

Sources, types, Causes and consequences of water pollution; water pollutants (organic, inorganic, biological and radioactive pollutants); Marine pollution; Thermal pollution; Oil pollution; Classification of wastewater; Bioindicators; Eutrophication;

Characteristics of water and wastewater: Sampling of water and wastewater; collection and storage; Physical, chemical, and biological characteristics of water and wastewater

Unit 3: Wastewater treatment **16 Hours**

Wastewater generation; Sewage treatment – Primary, secondary and tertiary treatment – process design and application; Principle, role and design of biological unit process in wastewater treatment - Aerobic (activated sludge process) and anaerobic (UASB) processes; Suspended, attached and hybrid reactors; operational parameters.

Wastewater treatment for small communities – Oxidation ditch, extended aeration system, SBR; Process design and operation of mechanically aerated lagoon and Waste stabilization pond system.

Unit 4: Sludge treatment **15 Hours**

Classification of sludge, Sludge treatment – Preliminary operation, Thickening, Conditioning, Dewatering, Filtration, Digestion and Drying of sludge, Sludge disposal.

Laws related to water pollution - Acts, policies and protocol

Course Outcomes

- Students will apply the water purification techniques
- Students will be able to use appropriate technology for wastewater treatment

Suggested readings

1. Metcalf and Eddy. (2015).Wastewater Engineering Treatment and Reuse. Mc Graw Hill Education (India) Private Limited.
2. Henze Harremoes Lacour Jonsoen Aruin. (2010).Wastewater Treatment (Biological and Chemical Processes. Springer (India) Private Limited.
3. John C., Trussell, Hand, Howe, George Tchobanoglous.(2012). Water Treatment (Principle and Design). John Wiley and Sons Inc. Hoboken, New Jersey
4. Frank R. Spellman. (2009). Water and Wastewater Treatment Plant Operations. CRCP Press Tylor and Francis Group
5. Edward A. Laws. (2018). Aquatic Pollution-An Introductory Text .John Willy and Sons, Ltd.
6. James K. Edzwald. (2010). Water Quality and Treatment. Mc Graw Hill Education (India) Private Limited

Course Code: EVS 523
Course Title: Energy and Environment

L	T	P	Cr
4	0	0	4

Course Objectives

- To understand classification, importance of renewable and non-renewable energy sources and its consumption pattern in the world and India

- To learn about principle, generation and applications of different conventional and non-conventional energy sources
- To understand the need, principle and methods of energy conservation
- To understand waste to energy conversion technologies and its recovery

Unit 1: Introduction **14 Hours**

Introduction to energy sources, Energy scenario in world and India, Potential and perspectives of various energy sources in India, classification of energy resources-conventional and non-conventional, renewable and non-renewable, environmental implications of energy resources.

Unit 2: Conventional energy **14 Hours**

Fossil fuels (Coal, petroleum, LPG and natural gas) – origin, composition and physico chemical characteristics and energy content, sources properties and production process; nuclear energy– fission and fusion, technologies – nuclear enrichment, nuclear reactors, nuclear waste disposal, policies and regulations.

Unit 3: Non -Conventional energy **16 Hours**

Prospects of renewable non-conventional energy, Types-solar energy, wind energy, hydel, tidal and geothermal energy, OTEC: introduction, principle, generation. Solar collectors, applications of solar energy: Solar water heating, solar heating and cooling of buildings, solar photo-voltaics, solar distillation, solar cooking and solar ponds. Basic components of wind energy conversion system, types and applications of wind energy.

Unit 4: Waste to Energy and Energy Conservation **16 Hours**

Bioenergy - Biomass energy as an energy source, characterstics of biomass, Energy plantations, Biomass conversion technologies. Types of biofuels - Biodiesel, bioethanol, biogas, biohydrogen - importance, production, technologies and applications.

Waste to resource recovery and recycling for energy, conversion technologies. Feed stocks, factors affecting biogas generation, Biogas plants: Classification of biogas plants, advantages and disadvantages of biogas plants, community biogas plants.Microbial fuel cell – principle, types and challenges. Environmental impacts of over exploitation of solar, wind and ocean energy. Energy conservation – principles and approach, energy conservation in buildings, green buildings, solar passive architecture, eco-housing, energy audit, national and international norms**.**

Course Outcomes

- Students will be able to apply technologies for energy generation
- Students will be able to apply learnt methods for energy conservation and energy management at home and organization

Suggested Readings:

1. Ahmed F. Zobana and Ramesh C Bansal. (2011). Handbook of Renewable Energy Technology. World Scientific Publishing Company.

2. Abbi, Y. and Jain Shashank. (2015).Handbook on Energy and Environment management. The Energy Resources Institute.
3. Bent Sørensen. (2017). Renewable Energy- Physics, Engineering, Environmental Impacts, Economics and Planning, Fifth Edition. Academic Press, Elsevier Inc.
4. Sergio C. Carpareda. (2013). Introduction to biomass Energy Conversions. CRC press.
5. Sukhatme, S.P. (2000).Solar Energy – Principles of Thermal Collection and Storage.Tata McGraw Hill.
6. European Wind Energy Association.(2009).Wind Energy- The facts: A guide to the technology,economics and future of wind power. Routledge

L	T	P	Cr
0	0	4	2

Course Code: EVS.524
Course Title: EVS Lab III (Water and Soil Analysis)

Course Objectives

- To train the students to carry out water and soil analysis of the samples

1. Determination of pH of water/soil sample.
2. Determination of conductivity/TDS of the water sample.
3. Determination of salinity of the water/soil sample.
4. Determination of dissolved oxygen in water sample.
5. Determination of COD and Total Organic Content.
6. Determination of BOD.
7. Determination of Total Kjehldahl Nitrogen (TKN), ammonical nitrogen etc. in water and soil samples.
8. Determination of fluoride content in soil/ water.
9. Determination of MPN for water samples by membrane filtration, pour plate and spread plate methods.
10. Determination of sulphate reducing bacteria in a given sample of water.

Course Outcomes

- Trained on the analysis of different physio-chemical parameters for soil and water samples

L	T	P	Cr
0	0	4	2

Course Code: EVS.525
Course Title: EVS Lab IV (Energy)

Course Objectives

- To provide hands on training to students estimation of fuel properties
- To acquaint with different equipments in energy research

1. Determination of Gross Calorific Value of fuel/straw samples using Bom Calorimeter.

2. To determine the kinematic viscosity of the sample by viscometer
3. To determine the flash point of the sample
4. To determine the cloud and pour point of the sample
5. To analyze the biogas composition by gas chromatography
6. To determine the volatile solids present in the sample
7. Preparation and characterization of biodiesel.
8. To estimate acid value of the sample
9. To estimate iodine value of the sample

Course Outcomes

- Trained on the analysis of various physicochemical properties of fuel samples

Elective I

L	T	P	Cr
4	0	0	4

Course Code: EVS 526
Course Title: Soil Pollution and Management

Course Objectives

- To understand about types of rocks and minerals, soil weathering and factors in soil formation
- To learn about plant available soil nutrients and soil sampling
- To understand sources and impacts of soil pollution
- To understand causes and consequences of land degradation with special reference to soil erosion and salt affected soils
- To learn how to manage and conserve soil, reclamation and restoration of wastelands

Unit 1: Soil formation **16 Hours**

Definition, rocks, minerals, soil forming factors, soil weathering- types and processes, soil formation, soil horizon, soil profiles, composition of soil, soil biota and their function in soil, humus, Soil microbes in nutrient cycling, Soil types in India. Physico-chemical and biological properties of soil, sampling and analysis of soil quality

Unit 2: Soil pollution **14 Hours**

Definition, sources- point and non- point, soil pollutants – types and characteristics, routes. Soil pollutants – Types, pesticides – classification, formulation; residual toxicity, synthetic fertilizers, heavy metals, Industrial waste effluents and interaction with soil components.Effects and impacts of soil pollution, biomagnification.

Unit 3: Soil erosion **14 Hours**

Salt affected soil – Saline soils, Sodic soil, Usar, Kallar, Types of erosion – water and wind erosion, causes, soil loss equation. Land degradation – causes and impacts, types of waste lands in India, desertification and its Control.

Unit 4: Soil management **16 Hours**

Methodologies for soil conservation, conservation of arable land, techniques of reclamation and restoration of soil, wasteland reclamation, soil salinity management, remedial measures for soil pollution, bioremediation- insitu, exsitu, phytoremediation and biodegradation. Principles of weed management, Legal measures for land conservation at national and international level.

Course Outcomes

- Students would be able to explain soil formation, soil pollution
- Students would be able to management methods for restoring the land degradation

Suggested Readings

1. Alfred R. Conklin Jr. (2014). Introduction to soil chemistry- Analysis and Instrumentation.John Wiley & Sons Inc.
2. Humberto Blanco and rattan Lal. (2008). Principles of Soil Conservation and Management. Springer Netherlands
3. Dorian Green. (2017). Elements of soil conservation. Koros Press Ltd.
4. Mishra, P.C. (2008). Soil Pollution and Soil Organisms. APH Publishing Corporation
5. Rathore, H.S. and Nollet, L.M.L. (2012). Pesticides- Evaluation of Environmental Pollution. CRC Press

Course Code: EVS.527
Course Title: Environmental Nanotechnology

L	T	P	Cr
4	0	0	4

Course Objectives

- To provide basic information on nanomaterials, its properties
- To understand various methods for synthesis and characterization of nanomaterials
- To learn about different environmental applications of nanomaterials
- To understand the fate and impacts of nanomaterials on environment and health

Unit 1: Synthesis and Advanced Characterization of Nanomaterials **15 Hours**

Physical and chemical method of synthesis for SWCNT, MWCNT, Metal nanoparticles and Metal oxide and Chalcogenide nanoparticles. Biologically Synthesized Nanoparticles, Nanostructures and Synthetic Nanocomposites - Protein-Based Nanostructure Formation - DNA-Templated Nanostructure Formation - Protein Assembly - Biologically Inspired Nanocomposites

Advanced Characterization Methods**:** Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy, Optical Absorption and Emission Spectroscopy, XPS – Working Principle, Instrumentation and Applications X-ray diffraction - Raman Spectroscopy and its Applications – Dynamic Light Scattering (DLS).

Unit 2: Properties of Nanomaterial **15 Hours**

Carbon nanotubes: electrical properties, vibrational properties, mechanical properties and applications of carbon nanotubes: field emission and shielding, computers, fuel cells, chemical sensors, catalysis – mechanical reinforcement. Semiconductor nanostructures – electronic properties, optical behavior and quantum confinement, characterization of semiconductor nanostructures.

Unit 3: Nanomaterials in Environment **15 Hours**

DNA, protein, molecular motors, aerosols, self-assembly and natural surfactants, Identification and characterization of Hazardous waste, Nano Pollution, Air, Water and Soil Contaminants.

Environmental Nano Remediation Technology - Nanotechnology for water remediation and purification: nZVI, Ag, Photofenton process, TiO_2 and its modification for efficient photodegradation, Nano Filtration for treatment of waste – removal of organics & inorganics and pathogens, Nanomembranes in Drinking water treatment, Nanomembranes in Sea desalination. Application of Nanomaterial in microfuelcell, fuel Cell, hydrogen storage.

Unit 4: Environmental Nanotoxicology **15 Hours**

Fate of nanomaterials in environment, environmental life cycle of nano materials, environmental and health impacts of nano materials, toxicological threats, eco-toxicology, exposure to nano particles – biological damage, threat posed by nano materials to humans, environmental reconnaissance and surveillance.

Course Outcomes

- Can synthesize nanomaterials of different types and apply them in various environmental applications

Suggested Readings:

1. Fulekar M. H. (2017). Environmental Nanotechnology, Taylor & Francis Inc.
2. Mark Wiesner and Jean-Yves Bottero. (2007). Environmental Nanotechnology: Applications and Impacts of Nanomaterials 1st Edition. McGraw-Hill Education.
3. Balaji S. (2010). Nanobiotechnology, MJP Publishers,Chennai.
4. Poole, C. P. Jr. and Owens F. J. (2009). Introduction to Nanotechnology, Wiley India, New Delhi.
5. H.F. Tibbals, Gabor L. Hornyak, John J. Moore, Joydeep Dutta (2008) Introduction to Nanoscience and Nanotechnology, CRC press

Course Code: EVS 528
Course Title: Natural Resource Management

L	T	P	Cr
4	0	0	4

Course Objectives

- To understand the importance of natural resources to environment and causes for resource depletion
- To learn about management and restoration of natural resources – forest, water, land, minerals and bioresources
- To understand various legal measures taken by national and international levels to conserve and restore natural resources

Unit 1: Forest resources **15 Hours**

Natural resources: Definition; Resource and Reserve; Classification of natural resources; natural resource degradation and conservation; Environmental impacts of resource depletion

Forest Resources:Forest cover of India and world; forest types, functions of forest – production and protection; Conservation of forests; forestry programmes – social forestry, farm forestry, urban forestry, community forestry; deforestation; Exploitation of forest resources; Afforestation; Dessertification; Forest policy.

Unit 2: Water and Marine resources **15 Hours**

Water Resources: Surface, ground water, marine and brackish water resources - assessment and utilization;Rivers and Lakes in India; hydrological cycle; Ground water depletion; Water logging and salinity; Water Conservation and management techniques; Rain water harvesting; Watershed management; Eutrophication; Restoration of Lakes; River cleaning, River action plans - Ganga and Yamuna action plan, Interlinking of rivers; conflicts over water.

Marine resources: Introduction to marine resources, Factors controlling abiotic resources and their distribution - polymetallic manganese nodules, phosphorites, hydrocarbons, beach placers evaporates, rare metals, corals, pearls and shells. Prospecting and mining of the ocean floor, Management of marine resources, demand, supply and production of marine resources. Policies and acts relating to ocean and land.

Unit 3: Land and mineral resources **15 Hours**

Land resources: Land degradation due to mining, exploration, industrialization, irrigation and natural disasters; Soil Erosion, Loss of soil fertility, Restoration of soil Fertility, Soil Conservation Methods; restoration of degraded land; Wasteland reclamation, Organic farming, green manuring, Wetland – definition, classification, functions, ecological importance and conservation.

Mineral resources: Mineral resources of India – Use and exploitation; mineral exploration, extraction; environmental impacts of extraction; Restoration of mining lands.

Unit 4: Bioresources **15 Hours**

Evolution strategies, adaptation, Vegetation, flora and fauna of India; Aquatic bioresource; Definition, Types and significance of biodiversity, values and threats, biodiversity conservation strategies; Bioprospecting. Biopiracy. REDD+; Conventions and protocols. Wild life resources and conservation measures

Human resources – population explosion, urbanization, industrialization, slums, poverty

Course Outcomes

- Explain the various conservation and restoration methods available for judicious use of the resources for sustainable future

Suggested Readings:

1. Kumar H. D. (2001).Forest Resources: Conservation And Management.East –West Press Pvt. Ltd., New Delhi
2. Anton Imeson. (2012). Desertification, Land Degradation and Sustainability. Wiley-Blackwell.
3. Verma, Sahu, Lal.(2009). Water Resource Management. Pentagon Press
4. Daniel P. Loucks, Elco Von Beek . (2017). Water Resource System Planning and Management. Springer
5. Anderson, David A. (2013) Environmental economics and natural resource management, Taylor and Francis 4th Edition.

SEMESTER III

Course Code: EVS.551
Course Title: Principles of Geospatial Technology

L	T	P	Cr
4	0	0	4

Course Objectives

The objective of the course is to provide knowledge of different aspects of geospatial technology, viz. remote sensing, GIS and GPS. The student will be able to grasp the principle and mechanism of these techniques so as to develop an understanding of the application of these techniques in various domains of environmental sciences, natural resource management and disaster management.

Unit 1: Introduction **13 Hours**

Concept of space and time; Global Positioning System (GPS); Types of Satellites;Google Earth; Bhuvan; GPS; GAGAN; Space Agencies in India; IRS Satellite Series.

Unit 2: Remote sensing **16 Hours**

Fundamentals, Electromagnetic radiations, Spectral reflectance, Sensors, Active and passive remote sensing; Types of platform; Types of orbits (Geostationary, Polar, Sun-synchronous); Scanning Systems (Pushbroom

and Whiskbroom); Types of Sensors; Data collection, Aerial Photography, Visual Image Interpretation, Digital image processing.

Unit 3: Concepts of GIS **16 Hours**

Elements of GIS; Map Projection; Data structures in GIS: Raster and Vector data GIS softwares, Hierarchical, Network and relational data, Geo-relational and object oriented vector data structure; Vector and Raster based analysis; Overlays operations; Map algebra; Network Analysis; Spatial analysis

Unit 4: Applications of Geospatial Technology **15 Hours**

Biodiversity, Land, air, ground water and water pollution studies, Coastal zone management, Mineral resources, Landslide, Earthquake, Tsuanami, Vegetation mapping, Wildlife monitoring, Wasteland mapping, Conservation of resources, Watershed Management.

Course Outcomes:

On completion of the course, the students will be:

- Aware of the basic phenomenon of remote sensing, GIS and GPS.
- Able to apply the applications of remote sensing, GIS and GPS to various domains of environmental sciences.

Suggested readings:

1. Thomas M. Lillesand, Ralph W. Kiefer, Jonathan W. Chipman (2012). Remote Sensing and Image Interpretation, Wiley
2. Qihao Weng (Ed.), (2011). Advances in Environmental Remote Sensing: Sensors, Algorithms, and Applications CRC Press, London
3. James Cambell, Randolph H. Wynne, (2011) . Introduction to Remote Sensing. The Guilford Press, New York
4. Andrew Skidmore (Ed.), (2010). Environmental modelling with GIS and remote sensing. CRC Press, London.
5. Qihao Weng (2010). Remote Sensing and GIS integration- Theories, Methods and Applications.,Mc Graw Hill

Course Code: EVS.552
Course Title: Instrumental Methods of Analysis

L	T	P	Cr
4	0	0	4

Course Objectives:

The objective of the course is to develop analytical skills of the students for environmental monitoring of various environmental pollutants using standard national and international protocols.

Unit 1: Quantitative analysis **13 Hours**

Acid-base, complexometric, precipitation and redox titrimetry.Gravimetric analysis – total solids, suspended solids and volatile solids.

Unit 2: Instruments **15 Hours**

pH meter, Conductivity meter, TDS meter, DO meter, Salinity meter, Ion Selective Coulometry, Anode and cathode stripping voltammetry, dropping mercury electrode(DME), merits and demerits of DME.

Unit 3: Spectrometric and Thermogravimetric Methods **16 Hours**

U.V. spectrophotometer, fluorescence, Flame photometry, Atomic absorption and atomic emission spectrophotometry, molecular structure determination using X- ray, fluorescence and X-ray diffraction, different types of mass spectrometry and surface plasma resonance.
Thermogravimetric Analysis, Differential Scanning Calorimetry.

Unit 4: Separation/ Chromatographic Techniques **16 Hours**

Partition coefficient, chromatography, general chromatography, chromatographic methods: Paper, Thin Layer chromatography, Column, High Performance Thin Layer Chromatography (HPTLC), Gas Chromatography (GSC and GLC), GC-MS, High Pressure Liquid Chromatography, Ion Exchange chromatography, Ion/Size Exclusion Chromatography and Electrophoresis.

Course outcomes:

On completion of the course, the students will be:

- Trained in analytical and instrumental skills required for environmental monitoring of pollutants.
- Able to design and carry out a method of environmental chemical analysis and research.

Suggested readings:

1. Skoog D. A., Holler F.L. and Crouch, S. R.(2007). *Principles of instrumental analysis,* Thomson Brooks/Cole Publishers, USA
2. Holler F. J, Crouch S.R, (2014). Skoog & West's Fundamental of Analytical Chemistry, 9th edition. Publisher, CENGAGE learning.
3. Patnaik, P. (2010); *Handbook of environmental analysis,* CRC Press, USA
4. Wiersma G.(2004); *Environmental monitoring,* CRC Press, UK.
5. Eaton, A. D., Clesceri, L.S., Rice, E.W. and Greenberg, A.E. (2005); *Standard methods for examination of water and wastewater 21st Edition.* American Public Health Association, American Water Worker Association, Water Environment Federation, USA.

Course Code: EVS.553
Course Title: EVS - Lab VI (Instrumental methods and Geospatial techniques)

L	T	P	Cr
0	0	4	2

Course Objectives: The objective of the course is to develop the analytical skills of the students for handling instruments for quantitative analysis of various pollutants in environment. Besides, the students would gain some

expertise in handling remote sensing and GIS software for carrying out spatio-temporal analysis of environmental factors.

1. Google Earth – Calculation of ground distance, aerial distance, path and area of given features.
2. Georeferencing of toposheets and satellite Imageries
3. Digitization and thematic map creation.
4. Visual interpretation using IRS false color composite.
5. Digital image processing – supervised and unsupervised classification.
6. Change detection using Image Processing softwares
7. Hands-on for Image Processing and GIS Softwares – ARC GIS, ILWIS, ERDAS.
8. Calibration of volumetric glasswares Pipette, Burette and Volumetric flask.
9. Potentiometric determination of pH of water/wastewater and soil samples.
10. Conductivity of water and wastewater samples using conductivity and TDS meter.
11. Working, standardization of DO meter and determination of DO of sewage water.
12. Working, standardization of flame photometer and plotting calibration curve for metal ions.
13. Working, of chromatographic techniques TLC, Column, HPLC and GC-MS.

Course Outcome:
The students will be able to:

- Design various experiments for analysing the pollutants in environmental matrices.
- Perform hands-on exercises for remote sensing and GIS software.

Elective II

Course Title: Waste Management
Course Code: EVS 556

L	T	P	Cr
4	0	0	4

Course objectives: The course will provide a basic understanding of the concept, types, characteristics and composition of solid waste. The students will be able to study the various treatment and disposal options of solid and hazardous waste. Besides, they will also gain knowledge about the legal, institutional and financial aspects of management of solid wastes.

Unit 1: Municipal Solid Wastes **15 Hours**

Waste: Sources, classification of waste, generation rates, Traditional waste collection and disposalSources, composition, collection, transportation and characterization of municipal solid wastes – proximate and ultimate

analysis, transfer stations, waste processing – volume and size reduction, source reduction, recycling, waste minimization.

Unit 2: Hazardous Wastes **15 Hours**

Hazardous waste: Definition, sources, classification, collection, segregation, characterization, Treatment and disposal.
Radioactive wastes: Definition, sources, classification, collection, segregation, Treatment and disposal.
E waste: Definition, sources, classification, collection, segregation, Treatment and disposal.
Biomedical wastes: Definition, sources, classification, collection, segregation, Treatment and disposal.

Unit 3: Waste Treatment and Disposal **15 Hours**

Incineration, Combustion, Stabilization, Solidification, chemical fixation, encapsulation, Composting, Vermicomposting, Energy from waste - Biogasification - Anaerobic digestion, pyrolysis, refuse derived fuels; Landfill bioreactors Burning, open dumping - problems, Landfill – site selection, Sanitary and secured – structure, design, construction, operation and closure. Landfill leachate and gas management, Landfill bioreactors

Unit 4: Waste Handling Rules **15 Hours**

Waste management rules: EPA (1986) Section 25; Municipal waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, flyash rules, recycled plastics usage rules, batteries (management and handling) rules, Schemes and programmes of Government- Swachchh Bharat Abhiyaan.

Course outcomes:

On completion of the course, the students will be able to:

- Carry out characterization of solid waste.
- Apply various treatment and disposal techniques to solid waste management.
- Understand the various legal framework of solid waste management.

Suggested Readings:

1. Williams, Paul T. (2013) Waste treatment and disposal, John Wiley Publishers.
2. Cherry P M (2016). Solid And Hazardous Waste Management. CBS Publisher and Distributors Ltd.
3. William A. Warwell; P. Aarne Vesilind (2012). Solid Waste Engineering. Cenage Learning
4. Johri, Rakesh (Ed.), (2009) E-waste : Implications, regulations and management in India and Current global best practices, TERI press.
5. Letcher, Trevor M. (Ed.) (2011) Waste: A handbook for management, Academic Press London.
6. Sahai, Sushma (2009) Bio- medical waste management, APH Publishing.

7. R E Hester (ed.); Roy M Harrison (ed.) (2008) Electronic waste management: design, analysis and application, Cambridge Royal Society of Chemistry.

L	T	P	Cr
4	0	0	4

Course Code: EVS 557
Course Title: Ecotoxicology and Occupational safety

Course Objectives: The objective of the present course is to acquaint the students with various aspects of environmental toxicology and the health hazards and the safety measures to be followed in industrial environment.

Unit 1: Introduction to Toxicology **15 Hours**
Definitions, Classification, Origin and General Nature of Toxicants in Environment, concepts; Toxic chemicals in the environment - air, water & their effects; Basic Probit analysis; Toxicants – Toxicity, mechanism of toxicity - Acute, sub-acute, chronic, dose effect, LD 50, LC 50 and response safe limits; IT, IC, LD_{80}, LD_{90}, LCIC, Dose response relationship, concentration response relationship; Influence of route of administration; determination of toxicity of chemicals.

Unit 2 Toxic Mechanisms **15 Hours**
Bioaccumulation and Biomagnification of toxic materials in food chain, detoxification, bioconcentration; Toxicology of major pesticides and heavy metals (Aluminium, arsenic, cadmium, chromium, lead and mercury) - biotransformation, biomonitoring, residual effects; bioindicator– definition, groups and examples.

Unit 3: Bioassays **15 Hours**
Concepts, types, characteristics and significance of bioassay; Bioassay test models and classification - Microbiol, algal, invertebrates and alternative toxicity tests; Immunotoxicity, histotoxicity, cell toxicity. Ecotoxicology – Legislative perspectives.

Unit 4: Occupational Health **15 Hours**
Occupational hazards in industries and other sectors, Safety requirements and Measures; Occupationally induced illness, non-occupational illness, discomfort at work, Occupational diseases- Pneumoconiosis, Silicosis, Anthracosis, Byssinosis, Bagasosis, Asbestosis, Farmer's lung, Metal poisoning, Occupational cancer, Occupational dermatitis; Radiation, fire and explosion hazards Hazards; occupational health practice; risk assessment techniques for accidental release of toxic and inflammable materials; Role of WHO in occupational health. Occupational health Standards - ISO.

Course outcomes:
After completion of this course, the students will:
- Know about the environmental toxicants and their effects.
- They will get to know about the methods of prevention and control of occupational health diseases, accidents and other hazards.

Suggested readings:

1. Newman, Michael C. (2010). Fundamentals of Ecotoxicology (3rd Edition). CRC Press, London
2. Newman, Michael C. (2015). Fundamentals of Ecotoxicology: The Science of Pollution (4th Edition). CRC Press, New York
3. Michael C., Clements, William H. (2008). Ecotoxicology: A Comprehensive Treatment Newman, CRC Press, London
4. Walker (2014). Ecotoxicology: Effects of Pollutants On The Natural Environment Colin CRC Press, London
5. Wayne G. Landis, Ruth M. Sofield, Ming- Ho Yu (2011). Introduction To Environmental Toxicology, CRC Press, New York

Course Code: EVS.558
Course Title: Natural Hazards and Disaster Management

L	T	P	Cr
4	0	0	4

Course objectives: This course is designed to familiarize the students with the concept of disaster; the components of disaster management cycle, vulnerability analysis and risk assessment of disaster. Besides, students would be made aware of the applications of remote sensing and GIS for monitoring and management of disaster. At the end, the existing legislations and various agencies pertaining to disasters shall be discussed.

Unit 1: Introduction to Disasters **15 Hours**

Introduction to Natural and Manmade Disasters; Floods –nature and frequency of flooding, flood hazards, urbanization and flooding, flood hydrographs, Dams barrages and river diversions; Landslides; Coastal hazards – tropical cyclone, coastal erosion, sea level changes, coastal zone management; Earth quakes - Seismic waves, quake resistant buildings and dams; Tsunamis; Volcanoes; Wild fires; Oil spills; Urban hazards and disasters.

Unit 2: Risk Assessment **15 Hours**

Pre-Disaster Management activities; Hazard and vulnerability analysis; emergency / contingency planning and post-disaster management activities; Development planning, planning environment, types of plans.

Unit 3: Geoinformatics in Disaster Management **15 Hours**

Role of GPS, GIS and Remote Sensing in disaster management - Landslides, Volcanoes, Tsunami, Cyclones, Urban and Forest fires, Landslides; Decision-making models and processes; Hazard monitoring, tracking and modelling; Early warning systems; Future satellites for disaster management..

Unit 4: Legislations and Policies for Disaster Management **15 Hours**

India Disaster Resource Network; Emergency Management and planning; Organization and structure for Emergency Management; Principles and Practice of Disaster Relief and Recovery; Disaster management policy;

Command and coordination in disaster management; Important statutes with provisions relevant to Disaster Management; Scope of Disaster Management Law with reference to Disaster Management Bill 2005, Local Administration and disaster risk reduction; Relief and Rehabilitation.

Course outcomes:

On completion of the course, the students will be able to:

- Describe disaster management, hazard, vulnerability and risk assessment.
- Deliberate how remote sensing and GIS can be used for effective management of disasters.
- Know the legal framework for disaster management.

Suggested Readings

1. Dr. S.R. Singh (2016). Disaster Management APH Publication Corporation, New Delhi
2. J.F. Shroder, M. Wyass (2014). Earthquake Hazard, Risk and Disasters, Elsevier
3. Bimal Kanti Paul (2011). Environmental Hazards and Disasters-Context, Perspectives and Management, Wiley & Sons, Ltd. Publication
4. Prof. Milan Konecny, Dr. Sisi Zlatanora, T. L. Bandrova (2010). Geographic Information and Cartography for Risk and Crisis Management Towards Better Solutions , Springer
5. A.K. Talwar, S. Juneja (2009). Natural Disaster Management, CommonWealth Publishers, New Delhi

Course Code: EVS 559
Course Title: Microbial Technology for Pollution Abatement

L	T	P	Cr
4	0	0	4

Course Objectives: The course shall help the students in developing an understanding of the types of microbes and their role in the environment. Besides, techniques of bioremediation using microbes, role of ecofriendly products and genetically modified organisms in the environment shall be discussed.

Unit 1: Introduction **14 Hours**

Microbial diversity in the environment, classification, role of microbes in environment protection, management of resources, bioindicators, biosensors - types and applications in environmental pollution detection and monitoring.

Unit 2: Environmental bioremediation **16 Hours**

Bioremediation, biotransformation and biodegradation**,** microbial interactions with inorganic pollutants - Microbial metal resistance; Microbial transformation; accumulation and concentration of metals; biosorption, bioleaching and biobenificiation, Bioaccumulation; Microbial leaching of low

grade mineral ores, molecular probes for organisms in mines and mine tailings, Petroleum pollutant biodegradation, Improved oil recovery. Biofertilizer, biopesticides from microbes in pollution abatement.

Unit 3: Ecofriendly products **16 Hours**

Development of biodegradable and eco-friendly products –biopolymers, bioplastics, use of micro-organisms in waste treatment, composting and methane production, biofuel- biohydrogen, bioethanol, Microbial fuel cells. Fermentation Technology- Bioreactors; industrial fermentation, types of fermentation processes; Enzyme Technology- Production, recovery, stability and formulation of Primary and secondary metabolites- Alcohol (ethanol), acids, solvents, antibiotics, amino acids; Extracellular enzymes -amylase, protease, glucose isomerase; Enzyme and cell immobilization and their industrial applications, Mushroom cultivation for waste management.

Unit 4: Genetically Modified Organisms and Environment

Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Microbial bioengineering for chemical biosynthesis, Transgenic plants-Pest and Disease Resistance, Herbicide resistant plants, Bt cotton, Genetically engineered insects**,** Relevance of Biosafety, Cartagena Protocol.
(14 Lectures)

Course Outcome:

The course shall help the students in:

- Understanding of the types of microbes and their role in the environment.
- Applying bioremediation techniques using microbes for degradation of pollutants
- Utilize different eco-friendly products

Suggested Readings:

1. Volodymyr Ivanov. (2011). Environmental Microbiology for Engineers. CRC Press
2. Raina M.Maier, Ian L.Pepper, Charles P. Gerba. (2009).Environmental Microbiology, Second Edition. Academic Press, Elsevier Inc.
3. Buckley, R.G. (2016).Environmental Microbiology. CBS Publishers & Distributors Pvt. Ltd.
4. Mark Wheelis. (2010).Principles of Modern Microbiology. Jones and Bartlett Publishers, LIC.
5. Bhatia, A.L. (2013). A Text book of Environmental Biology.I.K International Publishing House.

Course Code: EVS 560
Title: Industrial Visit/Field Visit and Report Writing

L	T	P	Cr
0	0	2	1

Course Objective: To apply theoretical and conceptual knowledge to field studies for developing a holistic understanding of environmental sciences.

Course Outcome:
The student shall be able to apply the theoretical knowledge gained in lectures to practical studies in field. Seminar presentation shall help in development of soft skills.

SEMESTER IV

Course Code: EVS 571
Course Title: **Environmental Impact Assessment and Auditing**

L	T	P	Cr
4	0	0	4

Course objectives:

- To understand the concept of EIA
- To familiarize students about EIA legislation in India.
- To learn key steps in the EIA process
- Overview of rules and regulations to develop an EIA
- Importance and process of Environmental Audit
- To understand the environmental risk analysis, characterization and assessment

Unit 1: Introduction **14 Hours**

Environment Impact Assessment - Principles, Origin, development, types, issues, problems and limitations, environmental risk assessment, environmental management plan, environmental impact statement (EIS), Strategic Environmental Assessment (SEA), EIA guidelines (1994) and notifications (Govt. of India 2006), Scope of EIA in project planning and implementation, Indian directions of EIA, Monitoring tools for EIA, surveys, spatial databases, experiments, models, Decision support system, Sources and collection of data for EIA, various appendices and forms for application.

Unit 2: EIA methodology **14 Hours**

Components of EIA, EIA methodology – project screening, scoping, base line data, impact identification, prediction, evaluation, mitigation. Assessment techniques – cost benefit analysis, analysis of alternatives, methods of prediction matrices, networks, checklists and overlays and assessment of impacts – air, water, soil, noise, biological, social, cultural, economical, environmental factors. EIA standards and guidelines, public participation-procedure of public hearing, presentation, review and decision making. Quality control – trends in EIA practice, evaluation criteria, expert system in

EIA, use of regulations. Documentation and monitoring – Generic structure of EIA Document, planning, collection, use of display materials, team writing, checklist, environmental monitoring guidelines and policies, Environment management plan, post audit.

Unit 3: Environmental Auditing and Management 14 Hours

Definition and types of audits, EMS, Guidelines for environmental auditing, methodologies for EnvironmentalAuditing, Matrix methods and Batelle method of auditing, Types of projects requiring Environmental Clearance, EAC, EIA case studies, Legal requirements for environmental auditing. Restoration and rehabilitation technologies, Environmental planning, urban planning, rural planning and land use pattern.

Unit 4: Environmental Risk Analysis 14 Hours

Definition of risk, environmental risk analysis – risk assessment and risk management. Basic steps in risk assessment – hazard identification, Exposure assessment, Dose-response assessment, risk characterization. Risk assessment in EIA

Course outcomes

On completion of this course students should be able to :

- Explain the major principles of environmental impact assessment
- Understand the different steps within environmental impact assessment
- Discuss the implications of current rules and regulations in relation to environmental impact assessment
- Key aspects of environmental audit and risk analysis
- Understand how to write EIA report
- Be able to access different case studies/examples of EIA in practice

Suggested Readings

1. Theodore, M.K. andTheodore, L. (2010).Introduction to Environmental Management. CRC Press
2. Kulharni, V. and Ramachandran. (2006). Environmental Management. Common Wealth of Learning and Indian Institute of Science.
3. Theodore, L. and Dupont, R.R. (2012). Environmental Health and Hazard Risk Assessment- Principles and Calculations. CRC Press.
4. Chitkara. M.G. (2013).Environmental Impact Assessment. APH Publishing Corporation.
5. Glenn W. Suter II. (2007).Ecological Risk Assessment, Second Edition. CRC Press.

Course Code: EVS 572
Course Title: Emerging Trends and Techniques in Environmental Science

L	T	P	Cr
4	0	0	4

Objectives:

- To understand the advanced waste water treatment processes
- Role of microbes in pollution abetment
- Understanding various eco-friendly methods of farming and their benefits
- Understanding sustainable development, efforts made internationally and nationally for sustainable development

Unit 1: Water and wastewater treatment **20 Hours**

Advanced wastewater treatment processes - Nutrient removal – nitrification, denitrification, ANAMMOX, SHARON, CANON process, Biological phosphate removal (BPR); Membrane processes - Fundamentals, membranes – types, classifications, microfiltration, ultrafiltration, nanofiltration and reverse osmosis, electrodialysis, Membrane fouling, cleaning and mitigation techniques; Ion exchange; Advanced oxidation process: Photocatalysis, ozonation – ozone/UV, ozone/hydrogen peroxide, hydrogen peroxide/UV, applications, oxidation of refractory organic compounds.

Bioreactors for wastewater treatment - Membrane bioreactors (MBR), Moving bed biological reactors (MBBR), anaerobic baffled reactor (ABR), Sludge disintegration methods; sludge pretreatment – thermal, physical, chemical, mechanical and biological. Energy recovery from wastewater: microbial fuel cells, microbial electrolysis cells, microbial desalination cell, biohydrogen production

Unit 2: Microbiology in pollution control **12 Hours**

Bioremediation processes reducing environmental impacts of synthetic pesticides, viral pesticides, Microbial degradation of naturally occurring compounds-cellulose, lignin, hydrocarbons. Bioprospecting, Biopiracy

Unit 3: Eco-agriculture **12 Hours**

Allelopathy, Natural plant products as bioherbicides, Organic farming, Eco-farming, Biofertilizers.Terrestrial Phytotechnology: Phytoremediation, Phytovolatilization, Phytodegradation, Phytostabilization - Aquatic Phytosystems: Blastofiltration, Rhizoremediation, Constructed wetlands, Algal blooms; fly ash treatment

Unit 4: Sustainable management **12 Hours**

Brundtland Commission, Sustainable development – principles and practices in relation to economics and ecology, green architecture and ground water recharge; CO_2 management, Carbon Sequestration, Environmental conferences- Stockholm, Rio, Johannesburg and Copenhagen Conferences; Kyoto Protocol –Radiative Forcing and Carbon cap; Clean Development Mechanism, Joint Implementation, Emission Trading, Certified Emission Reduction (CER) and Assigned Amount Units

(AAU), Land Use Land Cover Change and Forestry.

Course outcomes

At the end of this course, the student shall be able to

- Understand the importance of advanced waste treatment process
- Explain the process of carbon management and sustainable development
- Can get an idea about topics for project

Suggested Readings

1. Crittenden, J. C., Trussell, R. R. and Hand D. W. (2005). *Water treatment: principles and design,* 2nd edition, Wiley Publishers, USA.
2. Judd S (2011). *The MBR book: principles and applications of membrane bioreactors for water and wastewater treatment* 2nd Edition, Butterworth-Heinemann publishers, UK.
3. Okafor N. (2011). *Environmental microbiology of aquatic and waste systems*, *1st edition,* Springer publication, USA.
4. Parsons, S. (2004). *Advanced oxidation processes for water and wastewater treatment,* IWA Publication, London, UK.
5. Tchobanoglous G, Burton, F. L., Stensel H. D. (2002). *Wastewater engineering: treatment and reuse*, McGraw-Hill Science, USA.

Course Code: EVS.573
Course Title: Air & Noise: Pollution and Management

L	T	P	Cr
4	0	0	4

Course Objectives:

- Understanding air pollution and chemical composition of air
- Assess the effects of air pollution on related health impacts
- Understanding laws rules and related conventions
- Learning the techniques of air monitoring and instrumentation
- Understanding Air pollution control devises
- Noise Pollution and Control

Unit 1: Air Pollution **15 Hours**

Air pollution – world and Indian scenario, Sources and classification of air pollutants, Air pollutants effects and consequences.

Atmospheric Aerosols: Size Distribution, lognormal number, surface area, volume and mass distribution, dynamics, thermodynamics of aerosol and Nucleation phenomenon.

Laws,Rules and Convention: The air (Prevention and Control of Pollution) Act – 1981 and its Amendments, Geneva Convention on long range transport of atmospheric pollutants.

Unit 2: Air Monitoring **15 Hours**

Ambient air sampling using impactor, Cyclone, dichotomous and impingement devices, filter media selection. Adsorption and adsorption based sampling, Indoor environment monitoring.

Industrial Monitoring: Flow velocity and temperature monitoring, isokinetic sampling and compositional analysis, Flue gas analyzer principles for monitoring COx, NOx, SOx, hydrocarbon.
Air dispersion and Modelling: Plume behaviour and principles of air pollutants dispersion (Gaussian dispersion model) Plume rise estimation, Effluent dispersion theories and Atmospheric and Indoor chemical modelling.

Unit 3: Air Pollution Control Technologies 16 Hours

Particulates - filters, gravitational, centrifugal-multiple type cyclones, Scrubbers and electrostatic precipitators: Equipment descriptions Prediction of collection efficiency and Pressure drop. Adsorbents, PSA, adsorption cycle, rotary bed/fluidized bed, Condensation - contact condensers, shell and tube condenser, flaring. Gaseous Pollutants - absorption: Packed and plate columns. Low NOx burner, Wellman Lord Process, Fuel desulphurization and denitrogenation.
Vehicular Pollution Control: Combustion Cycle, Fuel/air ratio and Catalytic convertor; selective catalytic and selective non-catalytic reduction.

Unit 4: Noise Pollution 14 Hours

Definition, sources, properties of sound waves, Sound pressure, intensity, decibel, measurement and analysis of sound, Noise Indices, Sound absorption, Meteorological effects on Noise propagation, Effects and impacts on human, Noise exposure level and standards, Noise control, Preventive measures and abatement measures.

Course outcomes

On completion of this course students should be able to

- Acquired knowledge and understanding to evaluate air quality management
- Analyze the causes and effects of air pollution.
- understand the type and nature of air pollutants,
- understand methods of analysis of air pollutants and instruments involved in this
- The methods available for air and noise pollution control

Suggested Readings:

1. Thad Godish, Wayne T. Davis and Joshua S. Fu (2015). Publisher: Air Quality, C R C Press Taylor and Francis Group
2. Mahajan S P (2011). Air Pollution Control, The Energy and Resources Institute (TERI) New Delhi
3. Abhishek Tiwary and Jeremy Colls (2010). Air Pollution- Measurement, Modeling and Mitigation , Routledge Taylor and Francis group London and New York
4. Mudakavi J. R. (2010). Principles and Practices of Air Pollution Control and Analysis, I. K. International Publishing House Pvt. Ltd. New Delhi and Bangalore
5. Agarwal S K (2009). Noise Pollution **,** A P H Publishing Corporation New Delhi

Course Code: EVS 574
Course Title: Redrafting Environmental Science-I

L	T	P	Cr
2	0	0	2

Course Outcome:
To Prepare for Net and other competitive examinations

Unit I: Water management **7 Hours**
Hydrological cycle; Water as a universal solvent; Types, sources and impacts of water pollution. Water quality analysis; Indian standards for drinking water (IS:10500, 2012). Drinking water and wastewater treatment; Thermal, Marine Pollution and Radioactive pollution

Unit II: Air and noise management **8 Hours**
Composition of air; photochemical reactions in the atmosphere, Oxygen and Ozone chemistry; Photochemical smog. Sources, types and impact of pollutants; air sampling and monitoring; Indian National Ambient Air Quality Standards; dispersion of air pollutants - Gaussian plume model, line source model and area source model. Control devices for particulate and gaseous pollutants; Indoor air pollution, Vehicular emissions and Urban air quality. Noise Pollution: Sources, effects, noise indices (Leq, L10, L90, L50, LDN, TNI); Noise control and abatement measures

Unit III: Soil management **8 Hours**
Components of soils, minerals, weathering and soil formation, erosion, properties, soil types, biogeochemical cycles, soil pollution control, management and analysis.

Unit IV: Waste management and Environmental analysis **7 Hours**
Solid waste collection and transportation; Solid waste processing and recovery; Waste treatment and disposal of solid wastes; Hazardous waste, e waste, plastic waste, fly ash, biomedical waste management. Titrimetry, gravimetry, spectrophotometery and chromatography

Course Outcome:
To clear NET/GATE and other competitive examinations and help in admission to higher education

Course Code: EVS 575
Course Title: Redrafting Environmental Science-II

L	T	P	Cr
2	0	0	2

Course Objective:
To Prepare for Net and other competitive examinations

Unit 1: Environmental Biology **7 Hours**
Major concepts in Ecology, Ecosystem Dynamics- structure, function, types and characteristics, energy flow models, biomes. Population ecology, Community ecology, Biodiversity and its Conservation, Environmental Biotechnology

Unit 2: Environmental Geosciences **7 Hours**

Radiation Budget, Plate tectonics, Climate of India, Indian Monsoons, Natural Hazards and Disaster Management, Principles and Applications of remote sensing and GIS

Unit 3: Energy and Environment **7 Hours**

Sun as energy source, fossil fuels, nuclear energy, Renewable energy sources- solar energy, hydro-power, tidal energy, ocean thermal energy conversion, wind power, geothermal energy, bioenergy – Principle and applications.

Unit 4: EIA and Environmental Legislations **7 Hours**

Environmental Impact Assessment (EIA)- Objectives, methodologies, Risk Assessment, Environmental Laws in India, Environmental Conventions and Agreements, Current Environmental Issues in India

Course Outcome:

To clear NET/GATE and other competitive examinations and help in admission to higher education

Course Code: EVS.576

Course Title: EVS- Lab V (Air Pollution Sampling and Analysis)

L	T	P	Cr
0	0	4	2

Course Objectives: The objective of the course is to develop the analytical skills of the students for handling instruments for quantitative analysis of air pollutants in environment.

1. Calibration of flow meters for high volume sampler.
2. Study of TSPM, PM_{10} and $PM_{2.5}$ in ambient air.
3. Study the efficiency of the filter media for particulate matter.
4. Determination of SO_2, NO_x, Cl_2 and O_3 using UV-Vis Spectrophotometry.
5. Sample preparation for PAH analysis.
6. Sampling and analysis of Metal ion in ambient air.
7. Sampling and analysis of semivolatile organics in air samples.
8. Sampling and analysis of Benzene in ambient air.
9. Sampling and analysis of SPM in stationary sources.
10. Vehicular emission testing.
11. Sampling and analysis of Noise.

Course outcomes: The students will be able to design various experiments for analyzing the air pollutants