Savitribai Phule Pune University

Amendment

Three Year B. Sc. (Blended) Environmental Science

Course Syllabus

(Total 150 Credits)

(To Be Implemented for Academic Year 2019 – 2021)

Introduction

The SPPU instituted the innovative Bachelor Degree in Environmental Science known as **B. Sc. (Blended) Environmental Science** in collaboration with the University of Melbourne (UoM), Australia and the Indian Institute of Science Education and Research, Pune (IISERP) to strengthen science education at the undergraduate level.

The SPPU is among the top universities in the country and has been in the forefront for initiating innovative programs. The UoM is ranked #1 in Australia and it has been among the top 50 in the world. IISERP established by the Government of India to strengthen science education and research in the country has attained national and international recognition in a short span of a decade. It offers a holistic BS – MS program in Science covering the basic science disciplines.

The **B. Sc. (Blended) Environmental Science** program is a joint initiative of SPPU-UoM-IISERP offering a transparent and internationally recognized bachelor's degree in Environmental Science underlining clearly the teaching objectives and learning outcome. In the first two years of the degree program all four basic sciences (Biology, Chemistry, Mathematics and Physics) will be taught providing basic knowledge with **specialization in Environmental Science in the third year**. The UoM and IISER will provide with support in terms of special lectures, workshops, and quality assurance.

Objectives

- To introduce the fundamentals of science education.
- To enrich students' knowledge in all basic sciences.
- To help the students to build interdisciplinary approach.
- To inculcate sense of scientific responsibilities, social and environment awareness.
- To help students build-up a progressive and successful career in academics and industry.

Highlights of the Program

- The course will be run in collaboration with UoM and IISER
- Special lectures by expert faculty from UoM, IISER and other institutes.
- The UoM will provide online teaching of some topics from the syllabus.
- The course will be accredited by the UoM.
- The degree will be considered at par with that of UoM and the students will be eligible to pursue higher studies at UoM and other Universities in Australia.
- The students will be imparted solid training to enable them to pursue Masters and Integrated Ph. D. degrees in reputed institutes such as IITs, IISERs and Central Universities

Eligibility

First Year B. Sc. (Blended)

Higher Secondary School Certificate (10+2) or its equivalent Examination in Science stream with either PCM group (Physics, Chemistry & Mathematics) or PCMB group (Physics Chemistry, Mathematics & Biology) or PCB group (Physics, Chemistry & Biology).

Second Year B. Sc.

Students are not directly admitted to second year of B. Sc. (Blended) Environmental Science course. Those who pass 12 subjects (practical courses are mandatory to pass) out 16 the subjects (Semester I & Semester II combined) will be promoted to second year.

In addition to core subjects, all the students shall opt for UGC mandatory course in Environmental Studies during second year. This course will be in addition to core subjects. They shall pass this course in order to achieve eligibility for the 3rd year.

Third Year B. Sc.

Students are not directly admitted to third year of B. Sc. (Blended) Environmental Science course. Those who complete first year in totality and pass 10 subjects (practical courses are mandatory to pass) out 14 the subjects (Semester III & Semester IV combined) will be promoted to Third year B. Sc. (Blended) Environmental Science course.

ATKT rules in B. Sc. (Blended) Environmental Science course will be as per university guidelines.

Reservation and relaxation will be as per the Government rules.

Course Structure

Duration: The duration of **B. Sc. (Blended) Environmental Science** Degree Program shall be of three years.

Medium of Instruction: The medium of instruction for the course shall be English.

The course is a semester and credit system based course and is divided into six semesters of 14 weeks each. The total number of credits for each semester is 23 making a total of 92 credits during the first two years with instruction in all the four subjects (Biology, Chemistry, Mathematics and Physics). In the third year, the student specializes in Environmental Science. The Third year will comprise of two semesters having a total of 58 Credits. The entire three year course will have a total 150 Credits. The advantage for a student opting for Environmental Science specialization in the third year of **B. Sc. (Blended) Environmental**

Science is the possibility to pursue Master's degree in Life Sciences and Environmental Science in reputed institutes.

At **first year of under-graduation**, students will be given the basic information that includes – all basic science subjects as mentioned above. The topics include general and organic chemistry, calculus, introductory classical physics, waves, gravitation, unifying themes in biology, diversity of life, ecology, environment, etc. Relevant experimentation on these topics is included in practical courses. They will also be introduced to scientific writing and communication skills.

At the **second year under-graduation** level, students will be introduced to linear algebra, vectors, complex numbers, computing, electricity, magnetism, special relativity, physical chemistry, inorganic chemistry, reactions and synthesis, cell biology, genetic control principles of physiology, both animal and plant physiology, mechanism of evolution, and population biology etc. The relevant practical experiments are included to enrich the student's knowledge.

At the **third year under graduation level,** the environmental science students will be introduced with environment specific courses including Environmental Chemistry, Waste Management, Remote Sensing and GIS, Environmental law and ethics, Climate System Science. These students shall also undertake undergraduate level project work / dissertation during semester V & semester VI.

Examination and Grading

The course is based on credit system and the examination process consists of two parts: continuous assessment (internal 50%) and end semester examination (50%). The internal assessment will consist of Class Room Examinations (subjective/objective), Field Work, Viva-Voce, Home Assignments, Lab Work, etc. The grading will be as per the university norms applicable to credit system.

University Terms

Dates for commencement and conclusion for the first and second terms will be declared by the University authorities. Terms can be kept by only duly admitted students. The term shall be granted only on minimum 75 percent attendance at theory and practical course and satisfactory performance during the term.

Intake capacity of student: 48

Proposed Curriculum Structure for the B. Sc. (Blended) Environmental Science Course (Semesters I - IV)

Number of weeks in a semester: 14 (excluding holidays and one week mid semester examination)

Nomenclature: BIO: Biology. CHM: Chemistry. MTH: Mathematics. PHY: Physics. ENG: English; COMP – Computing; EVSB - Environmental Science, Geo – Earth Science

1 Credit = 1 Contact hour per week both for theory and lab courses

Semester I

New Code	Name	Credits		Total Lectures
MTH 101	Maths 1: Calculus	5	12 Lectures per Credit	60
PHY 102	Physics 1: I Introductory Physics	3		36
CHM 103	Chemistry 1: General Chemistry – Chemistry of life	3		36
BIO 104	Biology 1: Diversity of Life	3		36
PHY LAB 105	Physics Practical	2		24
CHM LAB 106	Chemistry Practical	2		24
BIO LAB 107	Biology Practical	2		24
ENG 108	English: Critical Reading, Writing, Communication	3		36
	Total	**23**		**276**

Semester II

Code	Name	Credits		Total Lectures
MTH 201	Maths 2: Algebra	5	12 Lectures per Credit	60
PHY 202	Physics 2: Modern Physics	3		36
CHM 203	Chemistry 2: Physical and Inorganic	3		36
BIO 204	Biology 2: Cell Biology	3		36
PHY LAB 205	Physics Practical	2		24
CHM LAB 206	Chemistry Practical	2		24
BIO LAB 207	Biology Practical	2		24
COMP 208	Computing	3		36
	Total	**23**		**276**

Semester III

Code	Name	Credits		Total Lectures
MTH 301	Maths 3: Vector Calculus, and Probability and Statistics I	5	12 Lectures per Credit	60
PHY 302	Physics 3: Quantum mechanics and Thermodynamics	3		36
CHM 303	Chemistry 3: Reactions and Synthesis	3		36
BIO 304	Biology 3: Functional Biology	3		36
PHY LAB 305	Physics Practical	3		36

CHM LAB 306	Chemistry Practical	3		36
BIO LAB 307	Biology Practical	3		36
	Total	**23**		**276**

Semester IV

Code	**Name**	**Credits**		**Total Lectures**
MTH 401	Maths 4: Differential Equations, and Probability and Statistics II	5	12 Lectures per Credit	60
PHY 402	Physics 4: Electricity, magnetism and Optics	3		36
CHM 403	Chemistry 4: Structure and properties	3		36
BIO 404	Biology 4: Genetics Evolution and Ecology	3		36
PHY LAB 405	Physics Practical	3		36
CHM LAB 406	Chemistry Practical	3		36
BIO LAB 407	Biology Practical	3		36
	Total	**23**		**276**
UGC Mandatory course – to be opted by all students (This course would be taught in either online mode or offline mode) (This course will be in addition to the core courses)				
EVSB 412	Environmental Studies (Theory & practical)	4		48

Semester V - New Syllabus to be adopted – Amendment

Subject Code	Title of the Subject	Credits		Total Lectures
EVSB 501	Environmental Chemistry	4		48
EVSB 502	Environmental Biotechnology	4		48
EVSB 503	Fundamentals of Ecology & Biodiversity	4		48
EVSB 504	Environmental Geosciences (Theory & practical)	3		36
EVSB 505	Water & Waste Water Management	3	12 Lectures per Credit	36
EVSB 506	Environmental Health and Toxicology	2		24
EVSB 507	Environmental Chemistry - LAB	2		24
EVSB 508	Environmental Biotechnology - LAB	2		24
EVSB 509	Fundamentals of Ecology & Biodiversity - LAB	2		24
EVSB 510	Project/ Dissertation	3		36
Total Credits		**29**		**348**

Semester VI - New Syllabus to be adopted – Amendment

Subject Code	Title of the Subject	Credits		Total Lectures
EVSB 601	Environmental Impact Assessment (Theory & practical)	4	12 Lectures per Credit	48
EVSB 602	Environmental Law and Policy	4		48
EVSB 603	Environmental Pollution and Control	4		48
EVSB 604	Remote Sensing and GIS	4		48
EVSB 605	Solid Waste Management	3		36
EVSB 606	Climate System Science	2		24
EVSB 607	Disaster Management & Mitigation	2		24
EVSB 608	Environmental Pollution and Control - LAB	2		24
EVSB 609	Remote Sensing and GIS - LAB	2		24
EVSB 610	Project/ Dissertation	2		24
Total Credits		**29**		**348**

Curriculum for B Sc (Blended) Program (Semesters I - VI)

And

Curriculum for B. Sc. (Blended) Environmental Science (Semesters V & VI) (Amendment)

Nomenclature: BIO: Biology. CHM: Chemistry. MTH: Mathematics. PHY: Physics. ENG: English; COMP – Computing; EVSB - Environmental Science, Geo – Earth Science

Semester I

MATHS 101
Differential Calculus: Graphs of functions of one-variable, trigonometric functions and their inverses, derivatives of inverse trigonometric functions, implicit differentiation, related rates. Partial derivatives, Limits, Partial Derivatives, Higher Order Partial Derivatives, Chain rule for partial derivatives, Directional derivatives, Application of Partial Derivatives- tangent planes, Normal Line, Extrema for functions of several variables and double integrals, Optimization, Gradient. **Integral Calculus**: Fundamental theorem of calculus, integration by trigonometric and algebraic substitutions, use of partial fractions with application to areas and volumes. Integrals Involving Roots, Integrals Involving Quadratics, Integration Strategy, Riemann integration, further techniques of integration and applications - Arc Length, Surface Area, Center of Mass/Centroid, Hydrostatic Pressure and Force, Probability, Improper integrals; Comparison Test for Improper Integrals, and Approximating Definite Integrals.
Differential Equations: First order differential equations-Linear Equations, Separable Equations, Exact Equations, Equilibrium Solutions, Second Order Differential Equations - Homogeneous and Nonhomogeneous, Second order linear differential equations with constant coefficients.

PHYSICS 102
Classical mechanics: Newton's laws of motion. Momentum and impulse. Translational, vibrational and rotational energy. Simple harmonic motion. Rigid body rotations **Waves and oscillations: r**eflection, refraction, superposition, resonance, energy transport, absorption, Doppler effect. Applications to water waves, acoustics, seismology **Gravitation:** Newton's law of gravity, Kepler's Laws.

Applications to astrophysics including orbital motion, escape velocity, apparent weightlessness

Fluids: Pressure, buoyancy, fluid flow, viscosity, surface tension. Applications to hydraulics, biology, biophysics, atmospheric physics, aerodynamics

Optics: Geometrical optics including dispersion, lenses, mirrors, interference, diffraction, polarisation. Applications to microscopy, imaging, vision, crystallography

Introduction To Energy: Importance of energy in science and society. Types of energy (mechanical, heat, chemical, nuclear, electrical). Law of conservation of energy. Energy transformations. Mechanical energy: force, work, kinetic and potential energy, PE diagrams, conservation of mechanical energy, bound systems. Electricity Basics.

CHEMISTRY 103

General Chemistry: Stoichiometry, equilibrium chemistry, acids and bases, valency, electrostatics, states of matter, The Periodic Table

Organic Chemistry: Alkanes, alkenes, alkynes, benzene, acids, aldehydes, ketones, functional groups, elimination reactions, addition and substitution reactions (nucleophilic and electrophilic).

The Chemistry of Life: Stereochemistry and biomolecular chirality. Biopolymers

The atmosphere of Earth; 2. Contaminant behaviour in the environment; Greenhouse effect - Global temperature-Acid rain and - Ozone layer depletion. Carbon Cycle; Nitrogen Cycle; Sulphur Cycle; CO formation in atmosphere; Organic Pollutants; Pollution from Combustion Systems; Coal Combustion; Photochemical Smog; Indoor Air Pollution, Dioxins, Furans, PCBs, Radon.

BIOLOGY 104

Unifying themes in biology: Origin of life, Origin of cell, Cell theory, Chemical composition of cell , RNA and DNA as the basis for life,

Complexity and Evolution: Structural organization in organisms-unicellular to multicellular organisms, structural complexity in life-symmetrical and asymmetrical

Domains of life: Prokaryotes and Eukaryotes, Five kingdom classification system, Tree of life –Protists,Fungi, Plants, Animals, Viruses and Prions, Evolutionary relationships

Diversity of Life: Basic principles of classification. Classification of Organisms, Taxonomy,

Linneus' System-Binomial System, Concept of species, Phylogeny, Systematics and cladistics

Major evolutionary features and characteristics of body plans of domains of life, mode of nutrition and examples of different domains with examples.

Prokaryotes: Bacteria and Archaea

Eukaryotes:

Protists(Protozoan and Algae: Slime moulds, amoebae, primary plastids – red and green algae, secondary plastids – brown algae lineage, dinoflagellates and apicomplexans, euglenoids)

Fungi (Zygomycetes, Basidomycetes, Ascomycetes, Deuteromycetes, Yeast and Yeast like fungi, common molds, dimorphic fungi)

Plants (Cryptogams: Thallophytes, Bryophytes, Pteridophytes, Phanerogams: Gymnosperms, Angiosperms, Dicots and monocots; Alternation of generations and the land plant life cycle, structure of the flower, double fertilization and seeds, Lichens)

Animals non- chordates and chordates (Porifera, Cnidaria, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Annelida, Hemichordata, Chordata, Class Pisces, Amphibia, Reptilia, Aves, Mammalia)

Viruses and Prions(Viral structures (capsid and genetic material), Different viral hosts, Animal and Plant viruses, Bacteriophages, Prions)

ENG 108 (Theory and Practical) – Syllabus

Sr. no	Theory	Practical
1	**Listening -** Overview, Question Types, Listening Tips, Completing the blanks, Making Assumptions, Understanding numbers Understanding the alphabet, Distinguishing similar sounds	Listening for - Description, Time, Frequency, Similar meanings, Emotions, Explanation, Classification, Comparison and contrasts, Negative meaning, Chronology
2	**Reading-** Overview, Question Types, Reading Tips	Using first paragraph to make predictions, Using the topic sentence to make predictions, Looking for specific details. Analyzing Questions and Answers, Identifying the tasks
3	**Writing-** Overview, Question types, Writing tips	Responding to task, Coherence and cohesion, Lexical resource, Generalizing and Qualifying, Grammatical range and accuracy

4	**Speaking-** Overview, Question type, Speaking tips	Introduction and Overview, Giving Information, Organizing and discussing a topic, Sequence, Comparing and contrasting Respond to follow up questions, Ask for clarification, Avoid short answers, Transition and intonation

Semester II

MATH 201
Analysis: Limits of real-valued functions, continuity and differentiability; Mean Value Theorem and applications; sequences and infinite series; Convergence/Divergence of Series, Absolute Series, Integral Test, Comparison Test, Limit Comparison Test, Alternating Series Test, Ratio Test, Root Test, Estimating the Value of a Series, Power Series, Taylor Series, Binomial Series **Vectors**: Basics, Magnitude, Unit Vector, Arithmetic, Dot product, Cross Product scalar and vector projections, plane curves specified by vector equations, **Complex numbers**: arithmetic of complex numbers, addition, subtraction, multiplication, division, sketching regions in the complex plane, De-Moivre's Theorem, roots of polynomials~~,~~

PHYSICS 202
Electricity and magnetism: Electric charge and field, conductors and insulators, electric potential, capacitance, resistance, electric circuits, magnetic field, Faraday's law of induction, Maxwell's equations, electromagnetic waves. Applications to electronics, household electricity and power supply, magnetosphere, communications **Special relativity:** Frame transformations, relativity of space and time, modification of classical mechanics, mass-energy equivalence. Applications to particle physics, twin paradox **Quantum physics:** photons, blackbody radiation, matter waves, quantisation in atoms, interaction of light with matter, x- rays. Application to atomic physics, lasers, and spectroscopy.

Nuclear physics: Atomic nucleus, radioactive decay, half-life, ionising radiation, nuclear fission and fusion. Application tonuclear energy, radiation safety, nucleogenesis, carbon dating. Effects of radiation on living tissue, background radiation, radon; units for radiation exposure; applications of nuclear technology, nuclear medicine, contaminant tracing, ion beam analysis

CHEMISTRY 203

Physical Chemistry: Kinetic theory of gases, energy, thermodynamic laws, redox chemistry and electrochemistry, chemical kinetics, structure determination, elementary quantum theory, atomic structure, atomic spectra, spectroscopy.

Inorganic Chemistry: Periodic behaviour of structure, bonding and chemical properties of Groups 1,2, 13-18. Transition metalchemistry (Groups 3-12). Coordination chemistry.

Water Pollution - Water Chemistry, Toxic Heavy Metals Ground and subsurface water contamination; Water pollution sources; Ground Water Pollution; Ocean Pollution.

BIOLOGY 204

Cell biology: Structure and function of cell components – nucleus, chloroplast, golgi complex, endoplasmic reticulum, mitochondria, lysosomes, vesicles, membrane, cell wall, flagella and cilia, cytoskeleton, spore, glycocalyx.

Endosymbiosis: chloroplast and mitochondria.

Cellular junctions: Desmosomes, Adherens junctions, tight junctions, gap junctions

Cell division: binary fission, budding, mitosis and meiosis, cell cycle, differentiation, aging and death

Types of cells and Multicellularity: different types of cells involved in embryonic development, level of organization - cells/tissues/organs, stem cells, cellular signaling

Central Dogma: RNA, DNA , Chromosome structure and function, genetic code and central dogma of life(Replication, Transcription and Translation during cellular growth), Protein trafficking, Gene expression – prokaryotic, eukaryotic.

COMP 208 (Theory and Practical) - Syllabus

Topics
Introduction to computing - What is computing; - Introduction to Electronic data processing; Electronic devices; - Information storage; access and management; - Key terms used in IT; - Introduction to computer networks;
Introduction to Open Source Software - History and use of Open Source Software - Examples of popular Open Source Software in different domains with special focus on Environmental Science, - Examples
System Analysis System thinking, steps of system analysis, defining the problem and designing the optimum solution, examples
Algorithms Design and components of algorithms, flowcharts, steps to design the optimum algorithm, analysis of algorithms, examples
Python Syntax: Variables and Assignments; variable types; input-output; arithmetic; functions and built-in function; If & While; Lists & Tables for loops, Simple Visualisations
Numerical Analysis: 1D integrals using Trapezoidal and Simpson's Rule; Euler's Method ; Generating Random numbers
Introduction to Scientific Computing - Definition, - Need and design of Scientific Computing processes, - Use of different software systems for Scientific Computing, - Examples
Optional
Mathematical Modelling: Agent Based Modelling; using NET Logo or similar tool, simple Harmonic Oscillator, Random Walks

Semester III

MATHS 301
Linear Algebra: Systems of linear equations, matrices and determinants; Real and complex vector spaces and linear maps, cross product, scalar triple product, lines and planes; vector spaces, subspace of a vector space, linear dependence-independence of vectors, dimension; linear transformations, eigen values, eigenvectors, inner products, diagonalization **Vector Calculus:** Vector fields, flow lines, curvature, torsion, gradient, divergence, curl and Laplacian. Integrals over paths and surfaces topics; line, surface and volume integrals; change of variables; averages, moments of inertia, centre of mass; Green's theorem, Divergence theorem in the plane, Gauss' divergence theorem, Stokes' theorem; curvilinear coordinates. **Probability and Statistics 1**: Probability: Theory basis of statistical inference. Probability and, random variables Standard probability distribution – Binomial, Poisson, Normal (definition, simple environmental examples, additive properties) applications to common univariate probability models. Joint behaviour of random variables, conditional probability, Markov chains. Statistics: Scope of statistics in environmental studies, Types of data- raw, grouped; Representation of data using frequency distribution diagram (Simple/Multiple/Subdivided bar diagram, Pie diagram),Graphs (Histogram, polygon, curve) Stem and leaf diagram; Population, sample and sampling methods (random, Stratified sampling); Descriptive statistics- Measure of central tendency (Mean, Mode, Median, Quartile), Measure of dispersion- Variance, Standard deviation, coefficient of variance; Skewness; Kurtosis

PHYSICS 302
Quantum mechanics: Quantum theory of light, the particle nature of matter, matter waves, quantum mechanics in one dimension and tunneling phenomena, atomic and molecular orbitals, the chemical bond. Applications to atoms, molecules, particle in a box. **Thermodynamics:** Thermal equilibrium, ideal gas and kinetic theory, equipartition of energy, heat and work, heat capacity, latent heat, enthalpy, thermodynamic processes; thermal systems and statistics, interacting systems, statistics of large systems, entropy, temperature and heat, pressure, chemical potential; heat engines, Carnot cycle, refrigerators, heat engines, throttling process; Helmholtz and Gibbs Free energies, and

phase transformations

Heat Energy And Kinetic Theory

Heat and Temperature. Internal Energy, Specific Heat. Ideal gas Equation. Kinetic theory interpretation of pressure and temperature. Work, heat, and the first law of thermodynamics. Adiabatic lapse rate. Radiant energy. Blackbody radiation.

CHEMISTRY 303

Reactions and synthesis: Synthesis and design of organic and inorganic molecules, molecular architecture and the energy transformations associated with chemical and physical processes. Topics covered include synthesis of simple poly-functional organic compounds, thermodynamically controlled reactions of s-, p- and d- block elements and thermodynamics

(Organic Synthesis C-C bond Forming Reactions, Organo-metallic Reagents in Synthesis, Carbonyl Compounds and Reactions, Redox (and important acid- base) Reactions, Exchange reactions., Substitution Reactions., Metal centered reactions.)

Energy Transformations and Thermodynamics, Energy quantization and Boltzmann distribution

Soil Pollution - Soil around us; Soil - Water Characteristics; Soil Erosion; Soil & Pollution; Water resources: Irrigation and Wetlands; Soil Pollution Management;

BIOLOGY 304

Principles of physiology: Energy management, maintenance of homeostasis, salts and water, metabolic processes (anabolism, catabolism), respiration and fermentation, regulation of metabolism (molecular signaling, genetic), growth kinetics, survival strategies (symbiosis, defense)

Animal physiology (Human): Respiration, digestion, nutrition and metabolism. Nervous system, Endocrine system, Excretion and osmo- regulation (water and salt balance), Cardiovascular system. Thermal regulation, Reproduction and development

Plant physiology: Water balance. Mineral nutrition and nutrient assimilation, Solute transport across membranes; Phloem translocation; Photosynthesis;

respiration and lipid metabolism; Secondary metabolism and defense; Growth and development (signal transduction, cell walls, growth and development, light responses,

hormones); Control of flowering; Abiotic stress

Microbial physiology: Aerobic and anaerobic respiration; Extremophiles; Symbiotic associations; Enzymes

Semester IV

MATHS 401
Differential Equations: Linear differential equations, both ordinary and partial, use of linear algebra to provide the general structure of solutions for ordinary differential equations and linear systems. Initial value problems, boundary value problems and eigen value problems arising from common classes of partial differential equations. Laplace transforms methods; separation of variables applied to simple second order partial differential equations. Fourier series solutions of the heat and wave equations; Fourier transforms. **Probability and Statistics 2**: Classical and Bayesian statistical methods; maximum likelihood, sufficiency, unbiased estimation, confidence intervals, hypothesis testing and significance levels. **Inferential Statistics**-Hypothesis, sampling distribution errors (Type I and II), Testing of hypothesis for mean and variance, Chi square test for fitting of distribution and Independence of attributes, ANOVA (one way and two way), Correlation, Scatter Diagrams, Covariance, Multiple and partial correlation. Environmental Applications include distribution free methods, goodness of fit tests, correlation and regression; the analysis of one-way and two-way classifications.

PHYSICS 402
Electricity and Magnetism: Electric field, Gauss's law in integral and differential form, scalar potential and gradient, Poisson and Laplace equations), the magnetic field (e.g. Ampere's law in integral and differential forms), Maxwell's equations in vacuum (differential forms), Maxwell's equations in matter (polarization, electric displacement, magnetic vector potential), time-varying electric and magnetic fields (Maxwell's equations in general form, wave equations for E and B, plane electromagnetic wave, Poyntingvector) **Optics:** Fourier optics, Fourier transforms in 1 and 2D, Dirac delta function and comb, discrete Fourier transforms and the sampling theorem, convolution, cross and autocorrelation. Fresnel and Fraunhofer diffraction, Polarized light including production and control of polarisation. **Energy Sources** Chemical energy. Energy in biology, photosynthesis, respiration. Energy use in the human body, energy content of food. Fossil fuels and their origin (coal, oil, natural gas).

Problems with fossil fuels, greenhouse pollution, peak oil. Alternatives to fossil fuels.

CHEMISTRY 403

Structure and properties: Stereochemical and electronic properties of molecules and the methods central to their study. Important elements of the subject include the spectroscopic characterisation and quantification of materials by a range of spectroscopic techniques, molecular orbital techniques and the application of approaches based on molecular symmetry and group theory to the understanding of molecular properties, stereo- selective reactions, bonding and spectroscopy. These topics have applications to advanced materials, light emitting polymers, chemical analysis and catalysis in biological and industrial systems.

Water Pollution Treatment -Introduction; Technological Approach; Chemical Degradation of wastes and Chemicals; Coagulation and flocculation; Photo-catalytic degradation of pollutants; Supercritical water oxidation.

BIOLOGY 404

Mechanisms of evolution: Mendelian genetics**;** Genetic diversity (mutation, recombination)**;** Genetic structure of populations (random mating/Hardy-Weinberg equilibrium)**;** Selection**;** Speciation and species concepts**;** Mechanisms of speciation (geographical, sexual, temporal, ecological)

Population biology: Nature of populations**;** Distribution and abundance of populations**;** Density independent, density dependent growth**;** Managing populations for production**;** Conservation biology**;** Epidemiology

Community ecology: Nature of communities**;** Community structure**;** Intra-community interactions**;** Symbiosis**;** Predation**;** Competition**;** Host- parasite interactions**;** Niche**.**

Dynamics of communities (perturbation and succession)**;** Biomes (communities on a global scale)

Ecosystems: Pond ecosystem; Food chains and webs; Pyramids (numbers, biomass, energy); Productivity (Primary and secondary); Biogeochemical cycles (water, C, N, P)

UGC Mandatory course – to be opted by all students (This course would be taught in either online mode or offline mode) (This course will be in addition to the core courses) - <u>Amendment</u>

Environmental Studies - I (Theory & practical)	
Topic Details	**Lectures**
Unit 1 : Multidisciplinary nature of environmental studies Definition, scope and importance Need for public awareness.	4
Unit 2 : Natural Resources : Renewable and non-renewable resources : 1. Natural resources and associated problems. 2. Forest resources : Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. 3. Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. 4. Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies. 5. Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. 6. Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies. 7. Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification. • Role of an individual in conservation of natural resources. • Equitable use of resources for sustainable lifestyles.	4
Unit 3 : Ecosystems 1. Concept of an ecosystem. 2. Structure and function of an ecosystem. 3. Producers, consumers and decomposers. 4. Energy flow in the ecosystem. 5. Ecological succession. 6. Food chains, food webs and ecological pyramids. 7. Introduction, types, characteristic features, structure and function of the following ecosystem:- a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	6

Unit 4 : Biodiversity and its conservation • Introduction – Definition : genetic, species and ecosystem diversity. • Biogeographical classification of India • Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values • Biodiversity at global, National and local levels. • Inida as a mega-diversity nation • Hot-sports of biodiversity. • Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts. • Endangered and endemic species of India • Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.	4
Unit 5 : Environmental Pollution Definition • Cause, effects and control measures of:- a. Air pollution b. Water pollution c. Soil pollution d. Marine pollution e. Noise pollution f. Thermal pollution g. Nuclear hazards • Solid waste Management : Causes, effects and control measures of urban and industrial wastes. • Role of an individual in prevention of pollution. • Pollution case studies. • Disaster management: floods, earthquake, cyclone and landslides.	4
Unit 6 : Social Issues and the Environment • From Unsustainable to Sustainable development • Urban problems related to energy • Water conservation, rain water harvesting, watershed management • Resettlement and rehabilitation of people; its problems and concerns. Case Studies • Environmental ethics: Issues and possible solutions. • Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. • Wasteland reclamation. • Consumerism and waste products. • Environment Protection Act. • Air (Prevention and Control of Pollution) Act. • Water (Prevention and control of Pollution) Act • Wildlife Protection Act • Forest Conservation Act • Issues involved in enforcement of environmental legislation. • Public awareness.	5

Unit 7: Human Population and the Environment • Population growth, variation among nations. • Population explosion – Family Welfare Programme. • Environment and human health. • Human Rights. • Value Education. • HIV/AIDS. • Women and Child Welfare. • Role of Information Technology in Environment and human health. • Case Studies.	5
Unit 8 : Field work • Visit to a local area to document environmental assets - river / forest /grassland/hill/mountain • Visit to a local polluted site-Urban/Rural/Industrial/Agricultural • Study of common plants, insects, birds. • Study of simple ecosystems-pond, river, hill slopes, etc.	16

Semester V - New Syllabus to be adopted – Amendment

EVSB 501 - Environmental Chemistry	
Topic Details	**Lectures**
Introduction to Green Chemistry What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.	4
• Principles of Green Chemistry and Designing a Chemical synthesis • Twelve principles of Green Chemistry with their explanations and examples; • Designing a Green Synthesis using these principles; • Prevention of Waste/ byproducts; • Maximum incorporation of the materials used in the process into the final products (Atom Economy); • Prevention/ minimization of hazardous/ toxic products; • Designing safer chemicals – different basic approaches to do so; • selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; • energy requirements for reactions - use of microwaves, ultrasonic energy; • selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; • use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; • designing of biodegradable products; prevention of chemical accidents; • strengthening/development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes	12
Water Chemistry - Reversible and irreversible reactions of water, Cations and anions in water and their sources, Mass Balancing, concepts of DO, BOD, COD, sedimentation, coagulation, filtration, redox potential.	6
Soil Chemistry - Chemistry of salt-affected soils and amendments; soil pH, EC, ESP, SAR; Soil Pollution Management;	6
Future Trends in Green Chemistry Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry, in sustainable development.	4
Student work - Assignments, Tutorials - Reviews of various research papers, reports, books - Presentations	16

Suggested Reading:

1. Manahan S. E, Environmental Chemistry, CRC Press2010
2. Girard J., Principles of Environmental Chemistry, Jones Bartlett Learning, 2014
3. A. K. Dey. Environmental Chemistry- New Age International publishers.
4. Bela Torok and Timothy Dransfield (ed.). Green Chemistry. 2017. Elsevier
5. V. K. Ahluwalia. 2013. Green Chemistry: A Textbook. Alpha Science International.
6. Harrison R., Principles of Environmental Chemistry, RSC 2007
7. Hanrahan G., Key concepts of Environmental Chemistry, Elsevier Inc. 2012

EVSB 502 - Environmental Biotechnology	
Topic Details	**Lectures**
Introduction & Basic concepts Definitions, scope of environmental biotechnology, applications in environmental resource conservation, sustainability, cleanup/bioremediation, biodegradation, transgenics/genetic engineering	4
Environmental Microbiology - Microbes in Environment - Biotransformation and Biodegradation	3
Biotechnological Tools and Techniques - Background, scope, various biotechnological tools and their significance for environmental analysis - Basics of microbial, plant and animal tissue culture techniques	4
Basics of recombinant DNA technology DNA/RNA, molecular cloning, Gene cloning Vehicles- vector: plasmids, cosmids, phage vectors- λ and M13, YACs, BACs, expression vectors, Agrobacterium vectors, host – properties of host	4
Enzymes for recombinant DNA technology Restriction enzymes, ligases, polymerases, alkaline phosphatase.	4
Transformation Techniques of introducing DNA in bacteria, animal and plant cells Selection of transformants & characterization	4
Polymerase chain reactions (PCR) and modifications	3
DNA sequencing techniques Maxam-Gilbert's method, Sanger's Dideoxy method, Automated DNA sequencing, Next generation sequencing	3
Biotechnology for Environment	
Concepts and applications Environmental Biotechnology of Bioremediation (including Phytoremediation), Biopesticides, Biocomposting, Biomining, Biomethanation, Bioleaching, Biosensors, Bioenergy,etc	5

GMOs and environment, International Conventions & Policies, biosafety and regulations, risks associated with production and release of GMOs- risk assessment, ways to reduce risks	4
Student work - Assignments, Tutorials - Reviews of various research papers, reports, books - Presentations	10

Suggested Reading:

1. Jördening, H.J. and Winter, J. eds., Environmental biotechnology: concepts and applications. John Wiley & Sons, 2005.
2. Singh, B.D. and Singh, B.D., Biotechnology expanding horizons. Kalyani publishers.
   2007.
3. Lehninger, A.L., Nelson, D.L., Cox, M.M., Lehninger principles of biochemistry. Macmillan, 2005.
4. Elliott, W.H., Elliott, D.C. and Jefferson, J.R., Biochemistry and molecular biology (Vol. 2001, p. 586). Oxford: Oxford University Press, 1997.
5. Wang, L.K., Ivanov, V., Tay, J.H. and Hung, Y.T. eds., Environmental biotechnology (Vol. 10). Springer Science & Business Media, 2010.
6. Rittmann, B.E. and McCarty, P.L., Environmental biotechnology: principles and applications. Tata McGraw-Hill Education, 2012.
7. Patel A.H., Industrial microbiology. Macillan India Ltd, 2000.
8. Nalwa, H.S. ed., Nanostructured materials and nanotechnology: concise edition. Elsevier, 2001.
9. Doble, M., Kruthiventi, A.K. and Gaikar, V.G., Biotransformations and bioprocesses. CRC Press, 2004.
10. Hambleton, P., Melling, J. and Salusbury, T.T. eds., Biosafety in industrial biotechnology. Glasgow: Blackie Academic & Professional, 1994.
11. A. H. Scragg, Alan H. Environmental Biotechnology: Oxford University Press
12. Martin Alexander. Biodegradation and Bioremediation: Academic Press.
13. Kirsten Heimann, Obulisamy Parthiba Karthikeyan, Subramanian Senthikannan Muthu, Environmental Footprints and eco-design of Products and Processes: Biodegradation and Bioconversion of Hydrocarbons. Springer.
14. Wang-Yu-Tong, Xue-Cheng Zhang, Shan-Qun Jiang, Xiang Dong. Integrated Biotechnology: Fundamentals and Applications. Stadium Press.
15. Neil Willey, Phytoremediation: Methods and Reviews. Humana Press.
16. John M.s. Barllett, David Stirling, PCR Protocols, Humana Press.

EVSB 503 - Fundamentals of Ecology & Biodiversity	
Topic Details	**Lectures**
Fundamentals of Ecology	
Ecology Definition, Concept, and Scope, Interdisciplinary science	1
Ecosystems – nature, structure and function, autecology and synecology, branches of ecology	1
Ecological Concepts - ecological succession, ecotone, edge effect, niche concept, homeostasis, ecological indicator plants and animals, concept of carrying capacity & limiting factors	2
Bio-geographical regions of India and its characters, principals of classification, key species of each region	3
Agro-ecological zones of India: basis of classification and characteristics in brief	2
Types of Ecosystems - Terrestrial (Forest Ecosystems, Grassland Ecosystems, Tundra Ecosystems, Desert Ecosystem), Aquatic (Freshwater Ecosystem, Marine Ecosystem)	3
Applied ecology - solutions for biodiversity conservation & climate related issues: restoration ecology, plants and microbes in conservation soils, restoration of land and degraded water bodies, carbon sequestration, Concept of ecological foot print	2
Fundamentals of Biodiversity	
Biodiversity Definition, Concept, Scope	2
Genetic Diversity: Introduction, Nature and Origin of Genetic Variations	2
Species Diversity: Definition, History and Origin of Species Diversity, Diversity Indices Based on Species: Species Richness, Species Abundance, Taxic Diversity	2
Nature and importance of Urban Biodiversity, Hotspots in India – concept and basis of 'hotspot' identification	2
Endangered, Endemic and Extinct Species of India: Threatened species categories of IUCN, threatened species of plants and animals in India and their reasons, Red data books.	2
Biodiversity loss: Introduction, factors causing loss of diversity, founder effects, demographic bottlenecks, genetic drift, inbreeding depression, process responsible for species extinction, migratory corridors – concept and importance	2
Biodiversity conservation: *In-Situ* and *Ex-Situ* conservation, social approach of conservation, Convention related to biodiversity conservation such as - RAMSAR sites, CBD, CITES. Biodiversity Act.	2
Biodiversity Management: Organizations Associated with Biodiversity Management, Organizations Involved in Financing Biodiversity Management.	2

Student Work - Case Studies - Review - Books , Scientific Journals - Group Discussions, etc - Field Visit	18

Suggested Reading:

1. Kormondy E. J., Concepts of Ecology, Pearson, 2017.
2. Odum, E.P. and Barrett, G.W., Fundamentals of ecology (Vol. 3, p. 5). Philadelphia:
   Saunders, 1971.
3. Krishnamurthy, K.V. (2003) An Advanced Textbook on Biodiversity – Principles and Practice. Oxford and IBH Publishing, New Delhi.
4. Dash M. C. and Dash S.P., Fundamentals of Ecology, Mcgraw Hill, 2009.
5. Ricklefs, R.E. and Miller, G.L., Ecology. W. H. Freeman & Co. 2000.
6. Smith, R.L., Smith, T.M., Hickman, G.C. and Hickman, S.M., Elements of ecology.
   Pearson Benjamin Cummings, San Francisco, CA, 1998
   Sharma PD (2000) Ecology and Environment. Rastogi Publications, Meerut, India.
7. Singh MP, Singh BS and Soma S. Dey (2004) Conservation of Biodiversity and Natural Resources. Daya Publishing House, New Delhi.
8. Krebs C.J. Ecology: The experimental Analysis of Distribution and Abundance, Pearson, 2016.
9. Chew S.C., The recurring dark ages: ecological stress, climate changes, and system transformation. Rowman Altamira, 2006.
10. Bharucha E. Changing Landscapes, The Cultural Ecology of India. Harper Collins
11. Publishers, India, 2017.

EVSB 504 - Environmental Geosciences (Theory & Practical)	
Topics	**Lectures**
Geosciences: Definition, branches, applications	**1**
Fundamentals of Earth System: Origin of Universe (Big Bang Theory), Solar system, Earth and Moon. Meteorites-types and origin. Cosmic abundance of elements, Distribution of elements in solar system and in Earth. Formation and characteristics of Earth Systems (Atmosphere, Lithosphere, biosphere and hydrosphere).	**3**

Earth structure: Structure of the Earth (Mechanical layers of earth), Geothermal gradients. Earth's magnetic and gravitational fields (origin and effects). Dynamic nature of earth (Plate Tectonics, Mountain building, earthquakes, volcanoes.	**3**
Earth's Composition: Minerals (Definition, characteristics, classification, basic rock forming minerals); Rocks (Definition, classification, rock cycle)	**3**
Surface Processes & Landforms: Processes (Physical, chemical, biological) and agents of weathering, erosion, transportation and deposition, products of weathering; Erosional and depositional landforms: Glacial, Aeolian, Fluvial, Coastal, shallow marine and deep marine.	**3**
Soil: Genesis of Soil; Lateritization; Soil Profile; Soil texture, structure; Bio-, Physico-, Chemical properties of soil; Soil Classification; Fertility; Land use and Land capability classification; Water-logging, salinization, desertification and degradation of soil.	**3**
Earth's natural resources: Occurrence and paragenesis of metallic, non-metallic minerals (metallic: Iron, manganese, copper, zinc, noble metals etc.; non-metallic: silica, asbestos, mica, carbonates, evaporites etc., coal, oil and natural gas). Surface and groundwater resources, Hydrological cycle.	**3**
Geomorphology: Landforms related to various agents (wind, ice, Water- fluvial, coastal and oceanic). Drainage types and density, Stream ordering, Hypsometric analyses.	**3**
Elements of Geological mapping: Geological mapping, Introduction to Topomaps, concept of scale, types of geographic projections, Representing lithological and structural elements on maps	**3**
Introduction to Applied Environmental Geology Landuse planning, Land reclamation, watershed management, etc.	2
Student Work - Field Visit - Lab Work	10

Suggested Reading:

1. The Earth System (3rd Edition) 3rd Edition- Lee R. Kump, James F. Kasting, Robert G. Crane.
2. Environmental Geology – K.S. Valdiya
3. Plate Tectonics & Crustal Evolution- Kent. C. Condie, 1997
4. A.D. Howward and I Remson : Geology in Environmental Planning

5. Todd, D.K.: Groundwater Hydrology.
6. Davis S.N. and Dewiest R.J.M.: Hydrogeology.
7. Textbook of Soil Science- T.D. Biswas and S.K. Mukherjee
8. The Nature and Properties of Soils, 14th Edition Nyle C., Brady and Ray R. Weil
9. Cesare Emiliani. Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment.
10. G.R. Thompson, & J. Turk. 1998.Introduction to Physical Geology.
11. A.D. Howward and I Remson : Geology in Environmental Planning.
12. T.D. Biswas and S.K. Mukherjee. Textbook of Soil Science.
13. Nyle C., Brady and Ray R. Weil.The Nature and Properties of Soils, 14th Edition
14. Holmes' Principles of Physical Geology 4th ed. 1993 Edition- Arthur Holmes (Ed) P. Mc L. D. Duff
15. D. Burrbank & R. S. Anderson. 2012.Tectonic Geomorphology
16. Umeshwar Prasad. Economic Geology: Economic Mineral Deposits 2nd Ed.

EVSB 505 - Water & Waste Water Management	
Topic Details	**Lectures**
Quantity & Quality of water - Water Requirements for various purposes [e.g. Domestic, Commercial and Industrial.] Variation in quantity of water and waste water, Factors affecting rate of demand.	2
Water Sources – Availability & quality of surface water & ground water. quality of raw water. (River zonation with refrence to developmental activity)	2
Impact of future growth and development and change in quality of life on water requirements. Need of water quality standards for domestic & industrial purpose. Specifications for drinking water (physical, chemical & bacteriological) by Bureau of Indian Standards & World Health Organization.	2
Water & Waste Water Treatment - Primary, secondary and Tertiary treatment process. - Advanced treatment methods e.g. Demineralization;Ultra filtration; Reverse osmosis; other membrane filtration systems, etc. - Supercritical water oxidation. - Recent Advancements in Water & Waste water treatment	12
Introduction to Parameters of Water & Waste Water Engineering & Design Criteria	5
Overview of National River Action Plan	1

Student Work - Review - Books , Scientific Journals - Visit to water & Waste Water treatment Plants, Industries, etc	12

Suggested Readings:

1. Garg S.K., Water Supply Engineering (Vol-I & II), Khanna Publishers
2. Peavy H.S., Rowe D.R. & Tchobanoglous G., "Environmental Engineering". McGraw Hill International Edition.
3. Karia G.L., Wastewater Treatment: Concepts and Design Approach, PHI, 2013.
4. Metcalf & Eddy, "Wastewater Engineering- Treatment and Reuse," Tata McGraw Hill, 4th Edn., 2003.
5. Rangwala. Water supply and sanitary engineering.
6. K.N. Duggal. Elements of Environmental Engineering
7. G. S. Birdie and J. S. Birdie. Water Supply and Sanitary Engineering
8. McGhee T. J., "Water Supply and Sewerage", McGraw-Hill, Inc., 1991.
9. Davis M. L. & Cornwell D. A., "Introduction to Environmental Engineering", McGraw- Hill, Inc.,1991.
10. Sawyer C. N., McCarty P. L., Parkin G. F., "Chemistry for Environmental Engineers", McGraw-Hill, 1994.
11. Punmia B.C., Environmental Engineering (Vol-I & II), Laxmi Publishers.

EVSB 506 - Environmental Health and Toxicology	
Topics	**Lectures**
Environmental Health	
Introduction Environmental Diseases and Public Health: Scope of Environmental health. Scientific understanding of causes, and possible future approaches to control of the major environmental health problems in industrialized and developing countries. and emerging global environmental health problems	**3**
Environmental Toxicology	
Introduction to toxicology, Principles of toxicology with reference to Environment, scope of toxicology. Concepts of Toxicology: Exposure, Dose Response Relationships, TLM and Lethality Studies. Biochemical basis toxicity – mechanism of toxicity and receptor mediated events, acute and chronic toxicity.	3

Toxicants in the Environment Toxic substances in the environment, its types, their sources and entry routes. Transport of toxicants by air, soil and water: transport through food chain -bioaccumulation and bio-magnifications of toxic materials in food chain.	3
Effects and Evaluation of Toxicity Classification, Methods of assessment, Types of Bioassay, bioassay test models and classification, Threshold Limit Value (TLV), LC_{50}, LD_{50}, toxicity testing: lethal, sub-lethal & chronic tests.	3
Student Work - Review - Books , Scientific Journals - Group Discussions, etc	12

Suggested Reading:

1. Shaw I.C. and Chadwick J. Principles of Environmental Toxicology, Taylor& Francis, 2008
2. Ming-Ho Yu, Humio Tsunoda, Masashi Tsunoda. (2011). Environmental Toxicology: Biological and Health Effects of Pollutants, 3rd Edition, CRC Press.
3. Stephen M. Roberts, Robert C. James, Phillip L. Williams (2015). Principles of Toxicology: Environmental and Industrial Applications. 3rd Edition, Wiley Publishers.
4. N Plant. (2003) (eds). Molecular Toxicology Taylor & Francis Publishers.
5. SataKe M, Mido Y, Yasuhisa H, Taguchi S, Sethi MS (2013) (eds). Environmental Toxicology Discovery Publishing House, India.
6. Subramanian MA (2010) (eds). Toxicology: Principles and Methods MJP Publishers, India.

EVSB 507 - Environmental Chemistry – LAB

1. Green Synthesis of the following compounds: adipic acid, catechol, disodiumc iminodiacetate (alternative to Strecker synthesis)
2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
4. Green counterpart of common organic reactions: Aldol, Friedel-Crafts, Michael, Knoevenagel, Cannizzaro, benzoin condensation and Dieckmann condensation.

5. Rearrangement reactions by green approach: Fries rearrangement, Claisen rearrangement, Beckmann rearrangement, Baeyer-Villiger oxidation.
6. Sampling and analysis of water / waste water (pH, EC, DO, BOD, COD, TDS, Alkalinity, Hardness, organic matter, residual chlorine, nitrate, sulphate, etc.)
7. Sampling and analysis of soil (pH, EC, Alkalinity, Hardness, organic matter, nitrate, sulphate, etc.)

Optional

1. Field Visit to nearby industries for studying different pollution control technology
2. Field Visit to a water treatment site, sampling, analysis, and reporting on the same;
3. Visit to a STP or ETP site and reporting

EVSB 508 - Environmental Biotechnology – LAB

1. Basic molecular/ microbial/ plant/animal culture based techniques
2. Genomic DNA Extraction of Bacteria/ plants from water/soil/ contaminated samples
3. PCR analysis of extracted genomic DNA samples
4. Electrophoresis Analysis of gDNA and PCR amplicons
5. Sequence analysis using BLAST platform

EVSB 509 - Fundamentals of Ecology & Biodiversity – LAB

1. Assessment of abiotic components in an ecosystem as physicochemical properties in – Atmosphere, Hydrosphere, Lithosphere
2. Assessment of biotic components in an ecosystem primarily pattern of organisms and habitat exposure
3. Assessment of biodiversity in a given geographical area – floristic diversity (citing categories of different life forms based on morphological features only)
4. Quadrat study for Herbacious Species/plants, involving random sampling to measure the abundance, density and frequency of various species in an ecosystem
5. Quadrat study for Faunal species, involving random sampling to measure the abundance, density and frequency of various species in an ecosystem
6. Field visit and reporting: Forest/desert/aquatic ecosystem – record biotic and abiotic components and interactions

Additional Practicals will be added to EVSB 507, EVSB 508 and EVSB 509, depending upon requirements of the subject.

EVSB 510 - Project – 2 Credits

Project-based learning offers an opportunity to the students to work independently under guidance of a supervisor. Students will be assigned to the on campus faculty/ research scientists from various national research institutes such as NCL/ IISER/ IITM etc/ experts from NGOs working in environmental field/others; under whose guidance he or she would work on a problem keeping the focus to enhance their own ability to critical thinking, identification of research problems and research gaps, formulate research objectives, formulation of research plan, and problem solving via execution of specific experiments, and develop specialized skills to handle specific problems. This would train the students to nurture their creativity and innovative ideas, collaboration/teamwork and leadership, communications, learning self-reliance and project management.

Adequate assessment requirements for individual marking are presentations with discussions and seminars on the working process and the results.

Semester VI - New Syllabus to be adopted – Amendment

EVSB 601 - Environmental Impact Assessment (Theory & Practical)	
Topic Details	**Lectures**
Introduction Sustainable Development challenges and need for EIA. Definition, aims and objectives of EIA. Concepts of EIA and Scope of EIA. Evolution of EIA. Benefits and Drawbacks of EIA process.	3
Legislation and Procedures EIA notification 2006 and other legislative requirements and administrative procedures India and its implementation, in India. Accreditation of EIA consultants by Quality Control of India – NABET requirements and guidelines.	4
Assessing Environmental Impacts: The EIA Approach - EIA as a planning process: developmental plans, policies and strategies for developmental projects - Steps in EIA process, - Impact Assessment methodologies - Identification, Prediction and assessment of impacts - Public Participation (PP) - Preparing an EIA report /Environmental Impact Statement (EIS)	8
Case Studies	12
Introduction to Strategic Environmental Assessment (SEA)	1
Student work - Reconnaissance surveys, - Field work for collecting baseline data, assessment of alternatives - Industry visits	20

Suggested Reading:

1. Judith, P. Handbook of Environmental Impact Assessment. Blackwell Science. 1999.
2. Marriott, B. Environmental Impact Assessment: A Practical Guide. McGraw-Hill, New York, USA. 1997.
3. Larry W. Canter. Environmental Impact Assessment. McGraw Hill, Inc, New York
4. Y. Anjaneyulu and Valli Manickam. Environmental Impact Assessment Methodologies. BSP publications, Hyderabad.
5. Morgan, R. K. (1998). Environmental impact assessment: a methodological perspective. Springer Us.
6. Paliwal, R. (2006). EIA practice in India and its evaluation using SWOT analysis. Environmental Impact Assessment Review, 26(5), 492–510.
7. The environment (Projection) Act 1986
8. The Environmental Impact Assessment Notification, 1994, GoI

9. Environmental Impact Assessment Notification, 2006
10. Environmental Impact Assessment Notification, 2020 (draft)

EVSB 602 - Environmental Law & Policy	
Topic Details	**Lectures**
Introduction to law and Policy • Sources of law, Concepts, Definitions • Difference between policy and law • Constitution of India and Environment (Global and National perspective)	5
International & Indian environmental movements • Historical background • Principles of international environmental law • Difference between Indian and Western environmentalism • Modern Environmental movements (Chipko, Apiko, Narmada bachao etc.) • Role of civil society in environmental movements	5
International Environmental Organizations • Various organisations and institutions (e.g. UNEP, UNFCC, IPCC, etc.) • Changing role of NGOs/ Institutions in conservation and protection of environment • Nexus between natural resources and tribal/ethnic communities • Natural resources and competing human rights.	5
Role of constitution in environment protection • Fundamental rights and duties, Article 48A, 51A (g), 58A, etc. **Environmental Legislation Indian Context**: • Water Act, 1974 • Air Act, 1981 • Indian Forest Act, 1927/1982 • Environment Protection Act, 1986 • The National Green Tribunal Act 2010 • National Environment Policy	5
Introduction to major international conferences/ conventions: • The Stockholm Declaration of 1972; • United Nations Conference on Environment and Development 1992; • Rio de Janeiro (Rio Declaration, Agenda 21); • Montreal Protocol 1987; • Kyoto Protocol 1997; • Ramsar convention: • Convention on Biological Diversity • Others	5

Overview of institutional framework in India • Agencies of Governance and their role in green governance • Government ministries, departments defining policies and laws (MoEF&CC, Pollution Control Boards, Forest Department, National Biodiversity Authority, etc) • Important autonomous boards, commissions and institutions working for protection/ conservation of natural resources (ZSI, BSI, BIS, Niti Ayog, etc.) • Green Justice network (Courts and specialised tribunals)	4
Student Work - Review - Books , Scientific Journals, Case studies - Group Discussions, etc	19

Suggested Readings:

1. Divan S. & Rosencranz A., Environmental Law and Policy in India. OUP, 2001.
2. Naseem M., Environmental Law in India Mohammad. Kluwer Law, 2011 International.
3. Venkat A. Environmental Law and Policy. PHI, 2011
4. Sands P., Peel J., Principles of International Environmental Law, CUP 2018
5. Abraham C.M. Environmental Jurisprudence in India. Kluwer Law International. 1999.
6. T S Doabia. 2017. Environmental and Pollution Laws In India. 3rd Edition. Publisher: Lexis Nexis
7. P. Leelakrishnan. 2016. Environmental Law in India. 4th edition. Publisher: Lexis Nexis.

EVSB 603 - Remote Sensing and GIS	
Topic	**Lectures**
UNIT 1: Remote sensing - Introduction, History Of RS, Components - EMR spectrum, Active and passive remote sensing, Atmospheric windows - Types of remote sensing: Optical, Thermal, Microwave, Hyperspectral, RADAR, LIDAR - Resolution of Remote sensing data: Spatial, Spectral, Radiometric and Temporal - Interaction of EMR with the earth's surface and atmosphere: Energy response mechanism: Reflection, Absorption, Transmission, Scattering, Refraction, Reflectance, Emission and scattering - Spectral reflectance curve for vegetation, soil, water - Types of platforms, Geostationary orbit and Sun-synchronous Polar orbit - Multi spectral scanning, Scanning Systems (Push broom and Whiskbroom etc);	16

- Indian remote sensing and sensors	
UNIT 2: GIS - Introduction, History Of GIS, Components - Shape of Earth-Geoid Spheroid Ellipsoid - Datum and projections: Conical, Azimuthal and Cylindrical. LCC Projection, UTM and Polyconic projections. Types of Datum. - Types of GIS data: Spatial, Attribute; Vector-point, line, polygon, Raster - Data structures in GIS: Spatial: Raster data, Vector data, comparative overview. Non-spatial data - Hierarchical, Network and relational data. - Acquisition of spatial data: Scanning, Geo referencing, concept of layer, digitizing, error detection and correction, concept of topology. - Spatial Analysis: Vector based: Overlays operations, point in polygon, line in polygon, polygon in polygon; single layer operations and Multilayer operations. - Raster based: Buffering, Network Analysis, generation of Thematic maps.	16
UNIT 3: Applications in RS and GIS - Aerial photography: Basic geometric characteristics of aerial photographs, Photo interpretation elements for visual interpretation - Satellite image processing and interpretation: Factors governing Interpretability, Elements of image interpretation. Image correction, rectification techniques. - Remote sensing products widely used and their features-sensors, uses, etc: LANDSAT, CARTOSAT, LISS, etc. - Global Positioning System (GPS), GLONASS, GAGAN: principles, applications - DEM, DTM, Terrain Analysis - RS GIS applications: Landuse - land cover changes; Natural hazards and hazard management; hydrology; monitoring water quality and soil quality; geology, forestry, agriculture, etc. - Use of GIS to represent environmental status and highlight environmental issues. - Latest trends in RS GIS: web GIS, drone mapping and surveying, wearable GIS, LIDAR	16

Suggested Reading:

1. Lillesand T. M., Keifer, R. W. & Chipman. Remote Sensing and Image Interpretation. John Wiley, 7th Edition, 2015
2. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems. 2nd Edition, Oxford University Press, 2006.
3. Joseph G. (2003): Fundamentals of Remote Sensing, Universities Press, Hyderabad.
4. Haywood, Ian (2000): Geographical Information Systems, Longman
5. Chang, Kang-taung (2002): Introduction to Geographic Information Systems, Tata McGraw-Hill.

6. Gupta, R. P. 2003. Remote sensing geology, Springer, New York
7. Ramsay : Trends in Geological Remote Sensing
8. Pandey : Photogeology
9. Paine D.P.: 1981, Aerial Photography and Image Interpretation for Resource Management, John Wiley and Sons, New York, 571 p.
10. Jense J. R., Remote Sensing of the Environment – An earth resource perspective. Pearson Education, 2nd Edition, 2013

EVSB 604 - Environmental Pollution and Control	
Topic Details - Air	**Lectures**
Air Pollution Meteorology & Chemistry Wind as a factor, Temperature structure, The role of atmospheric stability, Dispersion of air pollutants. Chemical Principles and Troposphere and Stratospheric Ozone Chemistry: Ozone formation & destruction, Polar Stratospheric Clouds (PSPs).	4
Air Pollution: Causes and Effects: Definition, Composition of air, Classification of air pollution, Sources, Effect of gaseous and particulate pollutants on animals, plant and human health, Economic effects of air pollutants, Vehicular Pollution , Industrial Pollution.	4
Air Quality Analysis Air monitoring instruments and techniques: SOx, NOx, O_3, C_6H_6, Pb, CO, Particulate Matters.	3
Air Pollution Control Technology : Equipment's and Basic Operating Principle; principle and working of – cyclones, scrubbers, settling chambers and electrostatic precipitators, fabric filters.	4
Topic Details - Noise	
Noise Pollution & Control Introduction to noise and vibrations, physics of sound and hearing, Noise Pollution, sources and effects. Noise control.	2
Noise Monitoring and Impact Criteria Noise measuring techniques, national standard for noise, noise monitoring methods, A-weighted Sound Level: The Basic Noise Unit; Maximum Sound Level (Lmax) During a Single Noise Event; Sound Exposure Level (SEL):Exposure from a Single Noise Event Hourly Equivalent Sound Level(Leq (h)); Day-Night Sound Level (Ldn): 24-Hour Exposure from All Events.	3

Radiation Pollution	
Radioactivity – types and measurement. Detection of nuclear radiations – G. M. counter, scintillation counter, semi-conductor detector. Radiation hazards and safety – natural and manmade. Types of radiations. Internal and external radiation hazards, safe handling methods, personal dosimeter, reactor safety. Interaction of radiation with matter. Units of measurements, half-life period, and radiation dose measurement. Biological effects and health hazards associated with radiation. Interaction of radiations with biological cells, somatic and genetic effects. Classification of radio-active wastes – gas, solid, liquid. Control measures – treatment and disposal of radio-active waste, generation of waste from various sources. ICRP recommendations. AERB classification, maximum permissible dose. Three miles and Chernobyl accidents.	6
Student work - Assignments - Reviews of various research papers, reports, books - Presentations - Visit to Industry/ Field	10

Suggested Reading:

1. Daniel A. Vallero. Fundamentals of Air Pollution.
2. L.T Molina & B.R Gurjar. Air Pollution: Health and Environmental Impacts.
3. L.K Wang & N.C Pereira. Advanced Air and Noise pollution Control.
4. S.C. Bhatia. Textbook of Noise Pollution & Its Control.
5. A. K. De. Environmental Chemistry.
6. Moore J. W., Inorganic Contaminants of Surface Water, Springer-Verlag
7. Gurjar B. R., Molina L.T., Ojha C.S.P. (Eds.), Air Pollution: Health and Environmental Impacts, CRC Press
8. Elaine M.A. and Bugyi G.(Eds.), Impact of Water Pollution on Human Health and Environmental Sustainability, Information Science Ref.

EVSB 605 - Solid Waste Management	
Topic Details	**Lectures**
Introduction Definitions, Historical development, Source and type based classification, chemical and physical composition, Factors affecting solid waste management: Climate, financial, cultural constraint, quality and quantity of waste. Environmental and health impacts due to solid waste and handling of it. Characterization: physical & chemical characteristics, implications for solid waste management.	4

Municipal Solid Waste, Industrial Solid Waste, Hazardous Waste, Biomedical & E-waste: Generation, Collection, segregation, Transportation	6
Treatments and disposal characterization, UN classification, Waste processing, Recovery of biological and chemical conversion products composting, biomethanation, RDF system, hydrolysis, Pyrolysis, plasma gasification, incineration, sanitary landfills.	4
Introduction to Solid Waste Management Rules (Solid Waste Management Rules, 2016; Plastic Waste Management Rules 2016; Biomedical Waste Management Rules 2016, etc.)	4
Case Studies	8
Student work - Assignments / Tutorials - Reviews of various research papers, reports, books - Presentations - Field Visits	10

Suggested Readings

1. M.S. Bhatt and Asheref Illiyan. 2012. Solid Waste Management: An Indian Perspective.
2. S. Bhatia. 2007. Solid and Hazardous Waste Management. Atlantic publication.
3. Goel, Sudha (Ed.). 2017. Advances in Solid and Hazardous Waste Management
4. M.N.Rao & Razia Sultana. Solid and Hazardous Waste Management
5. M.N. Rao, Razia Sultana, Sri Harsha Kota, Anil Shah, Naresh Davergave. 2016. Solid and Hazardous Waste Management: Science and Engineering. 1st Edition. Butterworth-Heinemann publication.
6. Handbook of Solid Waste Management, by George Tchobanoglous & Frank Kreith, 2nd Edition, Publisher McGRAW-HILL. DOI: 10.1036/0071356231
7. Integrated Solid Waste Management: Engineering Principles and Management Issues First Edition by George Tchobanoglous (Author), Hilary Theisen (Author), Samuel Vigil (Author). ISBN-13: 978-0070632370
8. Handbook of Solid Waste Management and Waste Minimization Technologies. 2002. by, Nicholas P Cheremisinoff Hardcover ISBN: 9780750675079
9. Industrial Waste Treatment Handbook. 2005. by Woodard & Curran, Inc. Hardcover ISBN: 9780750679633 Paperback ISBN: 9781493303199
10. Thermal Processing of Wastes 2010 By J. C. Jones ISBN: 978-87-7681-590-5
11. Transport and Chemical Rate Phenomena.1995. [Hardcover] By N. Themelis. Publisher: Taylor & Francis (July 17, 1995) ASIN: B00SB1MD32

12. Waste Management Practices - Municipal, Hazardous, and Industrial. 2014. By John Pichtel. ISBN - 13: 978-1-4665-8519-5
13. Industrial Waste Management Hardcover 2017 by Zander Ellis (Editor). ISBN-13: 978-1635491494.
14. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi, 2000.
15. White P.R. et al, Integrated Solid Waste Management, Lewis Publisher, 1989.
16. David L.H.F. and Liptak D. G., Hazardous waste and solid waste, Lewis Publisher, 2000
17. Oberoi N.K, Environmental Management, (2nd Edition) Excel Books, New Delhi, 2003.

EVSB 606 - Climate System Science	
Topic Details	**Lectures**
The Science of Climate Change - Introduction - History of Climate Change on Earth - The global carbon cycle - Green House Gases - Anthropogenic contributions	2
Climate modeling and feedback Mechanisms: - linkages between atmosphere, oceans, biosphere, etc.	2
Politics of Climate Change - Global Politics of Climate Change - United Nations Framework Convention on Climate Change (UNFCC) - Intergovernmental Panel on Climate Change (IPCC) - Kyoto Protocol, Paris Agreement, etc. - Indian contribution towards Climate Change	2
Impacts of Climate Change - Freshwater Resources - Terrestrial and Inland Water Ecosystems - Ocean Environments - Food Security and Food Production - Human Health, Livelihoods & Poverty	2
Energy & Climate Change - Current energy infrastructure (Global & Indian context) - Future technologies: carbon sequestration, biofuels, hydrogen fuel cells, etc	2
Climate Change Adaptation & Mitigation Strategies	2
Planning for Climate Change	2
Economic Effects of Climate Change & Introduction to Climate Change Finance	2

Student work - Reviews of various research papers, reports, books - Presentations - Group discussions - Visit to Industry/ Field	8

Suggested readings:

1. Lutgens & Tarbuck. The Atmosphere.
2. Cunningham & Cunningham. Fundamentals of Environmental Science: A Global Concern.
3. Chew S.C., The recurring dark ages: ecological stress, climate changes, and system transformation. Rowman Altamira, 2006.
4. William F. Ruddiman. Earth's Climate: Past and Future.
5. IPCC Reports on Climate Change

EVSB 607 - Disaster Management & Mitigation	
Topic Details	**Lectures**
Disaster - Definition, Classification of hazards/disasters and its types; Natural and Man Induced Disasters: Their causes, distribution and adverse effects	3
Natural: Volcanos, Earthquake, Floods, Droughts, Landslide Tsunamis, Storm and Cyclones, Cloud Bursts, Forest Fire, etc	3
Manmade: Industrial accidents, Stampedes, Pollution, Gas leaks, Radioactive leak, Water scarcity, Salinization of soils, Epidemics, Deforestation and Desertification, Earthquakes, Extreme heat, Urban flooding & Flashfloods)	3
- Disaster Management & Mitigation- Preparedness, Response, Recovery & Mitigation - Disaster Monitoring and Warning Systems; Remote Sensing and GIS for Disaster Management - Role of community in Disaster Management - Disaster Management Planning in India	3
Vulnerability & Risk Assessment - Identification and control of hazards, Risk Analysis – Definition, Various Techniques of Risk Analysis for Industries- HAZOP, HAZAN, Fault Tree Analysis, Event Tree, Dose-Response Relationship, etc	3
Student Work • Case Studies • Review - Books , Scientific Journals • Group Discussions, etc • Field Visit	12

Suggested Reading:

1. Bell F.G., Geological Hazards: Their Assessment, Avoidance & Mitigation, Taylor and Francis, 2003.
2. Alexander D., Natural Disasters, ULC press Ltd, London, 1993.
3. Bryant E., Natural Hazards, 2nd Edition, Cambridge University Press
4. B. Narayan. Disaster Management - APH Publishing Corporation
5. Chakrabarty U.K. Industrial Disaster Management - Asian company, new Delhi
6. Peter K. Lagoy. Risk Assessment- An Environmental Perspective - Jaico Publishing House, Mumbai
7. National Policy on Disaster Management, NDMA, New Delhi, 2009.
8. A Global Report - Reducing Disaster Risk, A Challenge for Development; UNDP Publication, 2004
9. Websites of Government of India

EVSB 608 - Environmental Pollution and Control – LAB

1. Measurement of particulate matter in air by grab sampling and gravimetric method.
2. Determination / Understanding levels of CO_2 in ambient air
3. Determination / Understanding levels of SOx in ambient air
4. Determination / Understanding levels of NOx in ambient air
5. Understanding of Noise Level Meter / DB meter
6. Understanding and comparing noise levels of different localities

Optional

Radiation Pollution:

1. Estimation of half-life of given sample.
2. Absorption coefficient of Aluminum (Al) for given β / γ source.
3. Study effect of distance on dose.
4. Study counting error

Optional

Field visit:

1. Visit to a local polluted site-Urban/Rural/Industrial/Agricultural, sampling, analysis and reporting,
2. Visit to industry having air-pollution control measures and reporting

EVSB 609 - Remote Sensing and GIS – LAB

1. Aerial photographs interpretation/ stereo images: Measurement of height on aerial photograph, Principle of relative tonality, minimum mapping unit, scale.

2. Google Earth- usage, measurement, historical data, placemarks, etc
3. Browsing, Downloading satellite data from BHUVAN & LANDSAT. Installing QGIS. Familiarization with software tools, data
4. Geo referencing toposheet &/or image registration
5. Digitization of features-point, line, polygon from toposheet/satellite image
6. Satellite image interpretation of different terrains/setup
7. Collection of data on field (GPS) and plotting on toposheet, creating Base maps.
8. Case study for understanding land use land cover change using temporal satellite data
9. Satellite image processing- image enhancement, contrast, mosaic, subset.
10. Visit to institute/company or small project work in groups

Additional Practicals will be added to EVSB 607, EVSB 608 and EVSB 609, depending upon requirements of the subject.

EVSB 610 - Project – 2 Credits

Project-based learning offers an opportunity to the students to work independently under guidance of a supervisor. Students will be assigned to the on campus faculty/ research scientists from various national research institutes such as NCL/ IISER/ IITM etc/ experts from NGOs working in environmental field/others; under whose guidance he or she would work on a problem keeping the focus to enhance their own ability to critical thinking, identification of research problems and research gaps, formulate research objectives, formulation of research plan, and problem solving via execution of specific experiments, and develop specialized skills to handle specific problems. This would train the students to nurture their creativity and innovative ideas, collaboration/teamwork and leadership, communications, learning self-reliance and project management.

Adequate assessment requirements for individual marking are presentations with discussions and seminars on the working process and the results.

Summer training / Internship

Even though summer training/internship is not mandatory or part of curriculum; Students will be encouraged to work as summer trainee or interns in other institutes/ laboratories/ industries depending upon the scopes and availability during summer/winter recess.

After the period of training, it is expected that students achieve the following:

- Recognize the duties, responsibilities and ethics at a professional position.

- Ability to apply knowledge learned to solve specific problems in relevant domain of science.
- Gain exposure and practical experience in the relevant field.
- Ability to prepare technical reports for the training.
- Ability to communicate effectively in the work environment.