Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Environmental Sciences

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Environmental Sciences)
Part-I

(For Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Course Code of Choice based Credit System for Postgraduate Science Programme

Sem	Course Type	Course Code	Course Name	Credits
1	Core Compulsory Theory Paper	EVSUT-111	Environmental Biology & Biodiversity	4
		EVSUT-112	Environmental Physics & Chemistry	4
		EVSUT-113	Earth, Ocean and & Atmospheric Sciences	4
		EVSUT-114	Environmental Statistics	4
	Core Compulsory Practical Paper	EVSUP-115	Environmental Sciences Practical Paper	4
2	Core Compulsory Theory Paper	EVSUT-121	Water & Soil Pollution: Management & Mitigation	4
		EVSUT-122	Air, Noise & Radiation Pollution: Management & Mitigation	4
		EVSUT-123	Environmental Law, Ethics & Policy	4
		EVSUT-124	Water & Wastewater Technology	4
	Core Compulsory Practical Paper	EVSUP-125	Environmental Sciences Practical Paper	4

Detailed Syllabus

SEMESTER – 1 (COMPULSORY)

EVSUT-111	ENVIRONMENTAL BIOLOGY & BIODIVERSITY (4 CREDITS)	Lectures
1.	**Environmental Biology: Concepts and Scope:** • Concept of Ecosystem; Biosphere as an ecosystem; its ecological processes and life support systems. • Ecotone, and Role of biological processes in remedial measures and restoration.	4
2.	**a) Fundamental Concepts of Ecology.** • Ecology: Definition, development and scope. Ecology as an experimental science • Ecosystems: concept, components and functioning. • Energy Fixation (photosynthesis and chemosynthesis) and energy flow through food chains (grazing and detrital) and webs (include Y shaped energy flow model). • Ecological efficiencies and pyramids. Trophic levels • Influence of environmental factors (including temperature, light, moisture, soil, nutrients) on organisms and their adaptations in response to them. **b) Ecology of Populations And Communities.** **(i) Population Ecology:** • Factors determining the abundance and distribution of a species • Factors leading to the commonness, rarity and vulnerability of extinction of a species. • Population Dynamics: Patterns of survival, age distribution, dispersal and rates of change. Attributes of K- selected and r-selected species, Population Growth. **(ii) Community Ecology:** • Competition, Exploitation (including herbivore, predation, parasitism), Mutualism (including commensalism, cooperation, symbiosis) • Food webs and concepts of niche and keystone species. • Nutrient cycling and retention: Biogeochemical cycles (Carbon, Nitrogen, Phosphorus), limiting factors and their tolerance	15

	• Succession, development, climax and stability of ecosystems (EXCLUDING Climax Theories), • Cake and other ecological models, model of successions	
3.	**Introduction To Plant And Animal Behaviour:** • Ethology and socio-biology: General definition and concept • Types of behaviour • Feeding Behavior: Herbivores, Carnivores, Parasites, Saprophytes, Response of prey / plants (deterrence, defence, reward). • Animal Architecture and use of tools • Circadian and other rhythms. • Migration, orientation, navigation, and homing. • Communication (including visual, olfactory, tactile, auditory, chemical) Aggression, Territoriality, Altruism. • Reproductive Behaviour: Courtship, Mating, Parental care, breeding systems. • Instinct and Learning: Genotype and phenotype behaviour. • Insect and Vertebrate Societies, Associations	**12**
4.	**Terrestrial and aquatic Biomes** • Climatic and edaphic factors of terrestrial biomes. Heinrich Walter's Biome Climate Diagrams • Classification of land biomes with their soil, climate and vegetation characteristics. Their natural history, wildlife, geography and human influences. • Mountain Biome: Replication of latitudinal changes in the altitudes of high mountains. • Terrestrial biomes, ecosystem diversity, forest and vegetation types in India. • Challenges and adaptations of life in aquatic biomes (freshwater: still and flowing, marine). • Freshwater Biomes (Rivers, streams, lakes, ponds) • Marine Biomes (including mangroves, coral islands, kelp forests, saltwater marshes, seashores, estuaries) and their natural history • Wetlands – definitions, types, ecological functions and resources.	**10**
5.	**Environmental Microbial ecology:** • Classification of microbes and their metabolism and ecology • Micro-organisms and their association with man, animals and plants.	**8**

	• Role of microbes in bio-remedial processes, ecological restoration and other environmental applications • Environmental factors affecting microbes, their cultivation and growth. • Concept of bioindicators, bioindicators as plants, animals, bioindicators in manmade environment, role of bioindicator in pollution control. • Fundamentals of microbial nitrogen fixation and other pathways in terms of enzymology.	
6.	**Concept of Carrying Capacity** Biotic and abiotic components of environment, concept of sustainability and carrying capacity, tragedy of commons, human population and food, water and energy security, present status of environment and future scenarios.	**6**
7	**Introduction to Biodiversity** Biodiversity: An inventory of Global and Indian biological resources and their present and potential uses; Values of biodiversity; threats to biodiversity; Strategy for conservation of bio-resources.	**5**
	Reference Books: 1. Environmental Science - Arms Karen 2. Principles of Environmental Science-Watt, K. E. F. (1973) McGraw-Hill Book Company. 3. Environmental Science –Noble, B .J. Kormandy, E.J. (1981). The way world works, Prentice-Hall Inc., N .J. 4. Environmental Science-Turk A. , Turk J. Wittes J.T. and Wittes, R.E. 5. Environmental Issues: Measuring, Analyzing, Evaluating, Abel, Daniel C. McConnell, Robert L. Abel, Daniel C. Edi. 2 Prentice Hall Publication 6. Chaudhuri AB and Sarkar DD (2003) Megadiversity Conservation, Flora, Fauna and Medicinal Plants of India's Hotspots. Daya Publishing House, New Delhi. 7. Gary K Meffe and Ronald Carroll C (1994) Principles of Conservation Biology. Sinauer Associates Inc., Massachusetts. 8. Groombridge B (Ed.) (1992) Global Biodiversity Status of the Earths Living Resources. Chapman & Hall, London. 9. IUCN (1992) Global Biodiversity and Strategy. 10. Sharma PD (2000) Ecology and Environment. Rastogi Publications, Meerut, India. 11. Singh MP, Singh BS and Soma S. Dey (2004) Conservation of Biodiversity andNatural Resources. Daya Publishing House, New Delhi. 12. Virchow D (1998) Conservation and Genetic Resources, Springer-Verlag,	

	Berlin. 13. Singh B, (1992).Social Forestry for Rural Development, Anmol Publishers, New Delhi 14. Raymond F Dasmann(1984), Environmental Conservation, John Wiley. 15. Kato, M. The Biology of Biodiversity, (1999), Springer Verlag, Tokyo. 16. Kotwal, P.C. and S. Banerjee(2002) Biodiversity Conservation – In Managed forest andProtected areas. Agrobios, India. **17.** Krishnamurthy, K.V. (2003)An Advanced Textbook on Biodiversity – Principles andPractice. Oxford and IBH Publishing, New Delhi.	

EVSUT-112	ENVIRONMENTAL PHYSICS AND CHEMISTRY (4 CREDITS)	Lectures
1	Estimation of various elements at major, minor, trace, rare level concentrations: choice of a technique, principle, merits and demerits of the techniques – neutron activation analysis, isotope dilution analysis, colorimetry, atomic absorption, spectroscopy, ICPAES, chromatography, HPLC, ion exchange chromatography, X-ray fluorescence, X-ray diffraction, Flame photometry, Polarography UV Spectrophotometer, Mass Spectrometry	15
2	Stoichiometry, Gibb's energy, Chemical Potential, Chemical equilibria, acid base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbon, radionuclides, Chemical bonding, chemical reactions and equations, Organic functional groups, classes of organic compounds. Free radical reactions, catalytic processes. Elemental cycles (C, H, N, S, O, P) and their environmental significance. 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.	10
3	**Fluids:** Pressure, buoyancy, fluid flow, viscosity, surface tension. Applications to hydraulics, biology, biophysics, atmospheric physics, aerodynamics **Waves and oscillations: r**eflection, refraction, superposition, resonance, energy transport, absorption, Doppler effect. Applications to water waves, acoustics, seismology **Optics:** Geometrical optics including dispersion, lenses, mirrors, interference, diffraction, polarisation. Applications to microscopy, imaging, vision, crystallography **Quantum physics:** interaction of light with matter, x- rays. Application to atomic physics, lasers, and spectroscopy	15
4	**Nuclear physics:** Atomic nucleus, radioactive decay, half-life, ionising radiation, nuclear fission and fusion. Application to nuclear energy, radiation safety, nucleo-genesis, carbon dating. Effects of radiation on living tissue, background radiation, radon; units for radiation exposure; applications of nuclear technology, nuclear medicine, contaminant	20

	tracing, ion beam analysis **Thermodynamics:** 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 laws of thermodynamics. Adiabatic lapse rate. Radiant energy. **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 polarization.	
	Reference Books 1. Environmental Chemistry by A. K. De 2. Destruction of hazardous chemicals- G.Lunn, E.B.Sandome 3. Hazardous substances in chemical lab-G.D.MuMivir 4. Essentials of Nuclear Chemistry, H. J Arnikar, Wiley Eastern Limited, 4th Edition.(1995)	

EVSUT-113	EARTH, OCEAN & ATMOSPHERIC SCIENCES (4 Credits)	Lectures
1.	**Earth: Origin, Structure, Dynamics & Composition** • **Origin:** Origin of Earth & its spheres (Lithosphere, Biosphere, Hydrosphere, Atmosphere) • **Structure:** Internal Structure of Earth - Core, Mantle and Crust; Thermal, Magnetic & Gravitation Fields of the Earth • **Dynamics:** Concepts of Plate Tectonics & Sea Floor Spreading, Mountain building (folding and faulting), Earthquakes, Volcanism • Composition: Igneous, Sedimentary & Metamorphic Rocks; Processes and formation; Characteristics of major Rocks and Minerals.	9
2.	**SURFACE PROCESSES & LANDFORMS** • Processes and agents of weathering, erosion, transportation and deposition; Cycles of erosion- Davis and Penck Models • Mass-wasting; • Erosional and depositional landforms: Glacial, Aeolian, Fluvial, Coastal, shallow marine and deep marine.	6

	• Concept of Engineering & Urban Geology	
3.	**Soil:** Genesis of Soil; Soil Profile; Soil texture, structure; Bio-, Physico-, Chemical properties of soil; Soil Classification; Soil types w.r.t. genesis; Fertility; Lateritization; Land use and Land capability classification; Water-logging, salinization, desertification and degradation of soil.	**4**
4.	**Hydrology:** • Concept of Hydrology & Hydrogeology • Hydrological Cycle (Precipitation, Infiltration, Surface Run off, Evapo-transpiration) • Surface & Groundwater Resources; • Vertical distribution of groundwater: Types of Aquifers & Springs; Hydrological properties of rocks: Darcy's Law, Storativity, Hydraulic Conductivity, Transmissivity, • Concept of Drainage Basin and Watershed.	**8**
5.	**Ocean Science:** • Ocean Basins and Physical structure of ocean floor; Oceanic environments • Vertical stratification of water column (Temperature, Pressure, Salinity, pH, Oxygen, CO2, Nutrients) • Waves, Tides, Currents, Tsunamis; Importance of winds & Hadley's Cell; Corriolis Effect; Geostrophic Currents; Ekman Spiral; Upwelling & Productivity; Surface; Thermohaline and Bottom water circulation	**8**
6.	**Earth Resources:** Occurrence, exploitation and environmental impacts Coal, Hydrocarbons and mineral resources.	**5**
7.	**Atmosphere:** • Evolution, Composition and Structure; Elements of weather and climate; Weather Parameters (temperature, wind pressure, relative humidity, rainfall); Climatology of weather parameters; Long and Short term climatic effects • Insolation; The energy system and its balance; Flux of solar system in the biosphere; Earth's radiation budget; Net radiation and latitudinal heat balance; Green House Effect and Human influence on radiation balance. • Atmospheric pressure, measurements & Distribution; Pressure & Wind Belts; local winds; Geostrophic & gradient winds; Air masses, Classification and modifications of air masses. Fronts, Classification of fronts.	**20**

	• Atmospheric moisture- Condensation; Forms of precipitation; Cloud Classification; Indian Monsoon; Inter-tropical Convergence Zone (ITCZ); • Walker Circulation: El Nino- La Nina • Atmospheric Stability & Instability; Dry and moist adiabatic lapse rate; • Environmental lapse rate, plume behaviour • Environmental Meteorology - Atmospheric chemical transport models; emission inventory- aerosol and gas pollutants; National Air Quality Standards and Indices; Dry and wet deposition fluxes of gas and aerosol pollutants; Intercontinental and hemispheric transport of air pollutants	
	Reference Books 1. The Earth System (3rd Edition) 3rd Edition- Lee R. Kump, James F. Kasting, Robert G. Crane 2. Holmes' Principles of Physical Geology 4th ed. 1993 Edition- Arthur Holmes (Ed) P. Mc L. D. Duff 3. Introduction to Physical Geology 1998. G.R. Thompson, & J. Turk 4. Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment- Cesare Emiliani 5. Environmental Geology – K.S. Valdiya 6. Plate Tectonics & Crustal Evolution- Kent. C. Condie, 1997 7. Tectonic Geomorphology – D. Burrbank & R. S. Anderson, 2012 8. Mineralogy: Berry Mason, Dietrich 9. Rock Forming Minerals: Deer, Howie, Zussman 10. A.D. Howward and I Remson : Geology in Environmental Planning 11. Soroie: Geology for Engineers. 12. Rise and Wateson: Elements of Engineering Geology. 13. Todd, D.K.: Groundwater Hydrology. 14. Davis S.N. and Dewiest R.J.M.: Hydrogeology. 15. Economic Geology: Economic Mineral Deposits 2nd Edn. Umeshwar Prasad 16. Economic Mineral Deposits 3rd Edition- Alan M. Bateman; Mead L. Jensen 17. Textbook of Soil Science- T.D. Biswas and S.K. Mukherjee **18.** The Nature and Properties of Soils, 14th Edition Nyle C., Brady and Ray R. Weil	

EVSUT-114	ENVIRONMENTAL STATISTICS (4 Credits)	
1.	**Foundation of environmental statistics –** Nature of environmental data: Survey based (empirical) and experimental data. Concepts of population and sample – Random variable and parameters of interest. Concepts of statistical inference, Simple random sampling for selection of sampling units for making observations.	6
2.	**Univariate data –** Frequency distribution and their properties (including Skewness and Kurtosis), Histogram, Frequency Curve and Ogive Curves. Measure of central tendancy: Mean, Median and Mode. Measure of Dispersion: Range, Variance, standard deviation and co-efficient of variation. Presentation of data: Summery statistics and graphical methods.	**8**
3	**Bivariate data -** Obtaining bivariate data by measuring two variables on a single sampling unit. Summary statistics for bivariate data: Mean, standard deviation and covariance, correlation coefficient. Scatter plot and its interpretation.	**8**
4	**Multivariate data –** Multivariate analysis, Regression Multivariate Analysis, PCA, Q-mode and R-Mode Factor analysis, Time-series data analysis, Moving averages, Wavelet analysis / Spectral analysis; Introduction to MATLAB	**10**
5	**Tests of Significance-** Chi- squared test: goodness of fit. Independence of attributes, T and F tests for significance	**5**
6	**Statistical models –** Distribution models: Normal distribution and its properties. Fitting of normal distribution. Calculation probabilities of different events for normal distribution. Standardization of data and approximation by normal distribution. Prediction models: linear and non- linear regression models, fitting a regression line and parabolic curve, estimating regression coefficients. Calculation of fitted values and residuals.	**12**

7	**Statistical models in environmental science-** Population growth model, Catch model.	**5**
8	**Statistical Quality Control (SQC) Technique-** Meaning of Quality/SQC, Control Chart for variables (X-Bar and R-Charts)	**6**
	Reference books: 1. Barnett Vic (2004) Environmental Statistics: methods and applications. 2. Ott, Wayne R. (1995) Environmental Statistics and data analysis. 3. Zar, Jerrold H. (1997) Biostatistical Analysis. Prentice Hall (India) 4. Nychka, Douglas and Piegorsch Walter W (1998) Case studies in environmental Statistics. 5. Manly Bryan F.J. (2001) Statistics for Environmental Science and Management. **6.** Walpole R. and Myem R. (1993) Statistics for engineers and scientists.	

EVSUT 115	PRACTICALS RELATED TO EVSC- 101, 102, 103 & 104 (4 Credits)
	EVSUT-111 FUNDAMENTALS OF ENVIRONMENTAL BIOLOGY & BIODIVERSITY 1. Determining the rate of photosynthesis in an aquatic plant (hydrilla or elodea) 2. Estimation of chlorophyll content from given plant leaves 3. Vegetation studies by line and belt and quadrates methods 4. To study wetland bird diversity 5. Phytoplankton and zooplankton analysis from freshwater samples 6. Estimation of Productivity of lake 7. Preparation of media for microbial culture, Isolation and culturing of microbes from soil / water samples, Gram Staining. 8. Bacterial growth curve 9. Enzyme analysis from soil samples
	EVSUT– 112 FUNDAMENTALS OF ENVIRONMENTAL PHYSICS AND CHEMISTRY 1. Preparation of samples and analysis using Chromatography 2. Determination of Nitrogen, Phosphorus, Sulphur 3. Estimation of halides in water samples by Potentiometry 4. Preparation of samples and analysis using titration 5. Preparation of samples and analysis using Flame photometer 6. Preparation of samples and analysis using Spectrophotometer / UV Spectrophotometer
	EVSUT – 113 EARTH, OCEAN & ATMOSPHERIC SCIENCES **1. Physical properties of minerals in hand specimen:** Quartz, Calcite, Aragonite, Orthoclase, Mica, Haematite, Kyanite, Hornblende, Chlorite, Baryte, Halite, Gypsum, Galena, Pyrite, Anhydrite, Apatite, Fluorite, Asbestos, Staurolite. **2. Physical properties of rocks in hand specimen** **Igneous:** Granite, Rhyolite, Basalt, Gabbro, Diorite, Dunite, Obsidian, **Sedimentary:** Conglomerate, Sandstone, Limestone, Shale, Laterite **Metamorphic:** Marble, Slate, Schist, Gneiss, BHQ 3. Textural analysis of soil & Ternary Plots 4. Slope analysis and aspect maps 5. Drainage analysis

	6. Estimations of dry and wet deposition fluxes of gases and aerosol pollutants 7. Exercises based on adiabatic lapse rates 8. Climatic maps and diagrams – circular, graph, wind roses 9. Study of distribution of surface oceanic currents and global conveyor belt 10. Study of distribution of different tectonic plates and boundaries
	EVSUT – 114 Environmental Statistics Practicals 1. Grouping of data and preparation of frequency distribution. Histogram and frequency polygon 2. Calculating mean, median and mode for grouped and ungrouped data 3. Calculating variance, standard deviation and coefficient of variation for grouped and 4. ungrouped data 5. Fitting simple linear regression. Plotting scatter diagram and regression line 6. Computing correlation coefficient and testing its significance for grouped and ungrouped data 7. Comparison between means of two independent samples. Paired t-test 8. Analysis of variance: one way classification 9. Analysis of variance: two- way classification 10. Multivariate Analysis : STATISTICA/ANOVA/SPSS **11.** Fitting statistical model of air pollution to data

Semester 2 (Compulsory)

EVSUT-121	Water and Soil Pollution: Management & Mitigation (4 Credits)	Lectures
1.	**Freshwater Pollution** Types and sources, Inorganic and organic pollutants responsible for water pollution: Biological pollutants; Pesticides; Radioactive pollutants, etc. effluent standards, Drinking water standards, Characteristics of Domestic waste, Characteristics of Agricultural waste. Consequences of water pollution: Effects on health, on biosphere and on economy. • Remedial measures of Freshwater pollution. • Case studies based on freshwater remediation using traditional and modern technology.	**16**
2.	**Ground water Pollution:** • Sources, groundwater contamination zones, groundwater remediation *in situ* and *ex situ* techniques; • bioremediation strategies of groundwater using bio-venting, bio-sparging, bio-slurpping, permeable reactive barriers; • groundwater monitoring using Piezometer, slug and pumping tests; • Darcy's Law for estimation of hydraulic parameters, Numerical simulation for aquifer yield prediction, Artificial recharge and induced infiltration, Land subsidence; • Coastal aquifers & Sea water intrusion • Environmental regulatory bodies preventing groundwater pollution; • Case studies based insight in to groundwater remediation techniques.	**16**
3.	**Marine Water Pollution:** • Sources, types and consequences; • Ballast water pollution • pollution due to off shore drilling, deep mining and oil extraction and other sources; prevention methods, control measures using bioremediation (bio-surfactants, microcosms), physical (booms, skimmers, absorbents etc) and chemical methods (dispersants, detergents etc). • Case studies based analysis of marine water pollution and prevention strategies.	**12**
	Soil Pollution and Control	

	• Types, Effects and sources and consequences. Mechanism of interaction of waste with soil. Transport processes –– biological process-microbial transformation of heavy metals. Specifications for disposal of sewage and effluent on land for irrigation and ground water recharge. • Methodology of wastewater disposal on land in India. Impacts of usage of land for solid waste disposal both municipal solid waste and industrial solid wastes (fly ash from thermal power station, lime sludge from pulp and paper mills). Disposal of hazardous solid waste (heavy metals, toxic organic compounds) on land and its impact on soil pollution. Deterioration of soil due to mining activities • Case study of restoration of land due to a disposal of fly ash, dumping overburden and tailing in iron ore extraction.	**16**
	Reference Books: 1. Groundwater In the Environment: An Introduction, Paul L Younger 2014, ISBN: 978-265-4636-7 2. Groundwater Hydrology, Bhagu R Chahar, McGraw Hill Education 3. Environmental Chemistry, B. K. Sharma 4. Environmental Chemistry and Pollution Control, S. S. Dara 5. Environmental Pollution, N. Manivasakam 6. Environmental Chemistry, Samir K. Banerji	

EVSUT-122	ENVIRONMENTAL POLLUTION II: AIR, NOISE AND RADIATION (4 CREDITS)	Lectures
1.	**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
2.	**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).	8
3.	**Air Quality Analysis** Air monitoring instruments and techniques: SOX, NOX, O3, C6H6, Pb, CO, Particulate Matters.	8
4.	**Air Pollution Control Technology :** Equipment's and Basic Operating Principle; Control of air pollution by fuel selection, principle and working of – cyclones, scrubbers, settling chambers and electrostatic precipitators. Control of gaseous pollutants – absorption, adsorption, condensation, vapor incineration. Equipments for control of air pollution – Cyclones, Wet scrubbers, Electrostatic precipitators, fabric filters, absorption.	8
5.	**Air Quality Management : Policy and Institutional Framework** Ambient Air Protection Policy, Air Quality Norms, Regulation of Emissions from Stationary & Non-Stationary Sources. Public Informing and Participation in Decision Making Process, Planning and Implementation of Ambient Air Protection Measures. Strategies for Air Pollution Control - Control of air pollution by fuel selection and utilization, by process modification or equipment, by site selection and zoning.	8
6.	**Air Pollution Episodes:** Case Studies	2
7.	**Noise Pollution & Control** Introduction to noise and vibrations, physics of sound and hearing, Noise Pollution, sources and effects.	6

	Noise control at source: Source path receiver concept, control by design, control by redress Noise control in the transmission path: Accoustical separation, physical barriers, Isolators and Silencers Protecting the receiver: personal protection device	
8.	**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; A Noise-Exposure Analogy for Leq and Ldn Investigation and assessment of impact of noise, Considerations in Applying the Noise Impact Criteria; Mitigation Policy Consideration; Determining the Need for Noise Mitigation.	6
9.	**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, 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.	10
	Reference Books 1. Fundamentals of Air Pollution – Daniel A. Vallero 2. Air Pollution: Health and Environmental Impacts – L.T Molina & B.R Gurjar 3. Advanced Air and Noise pollution Control – L.K Wang & N.C Pereira 4. Textbook of Noise Pollution & Its Control – S.C. Bhatia	

	5. Environmental Chemistry - A.K. De 6. Environmental Chemistry – B.K. Sharma	

EVSUT-123	ENVIRONMENTAL LEGISLATION, ETHICS AND POLICY (4 CREDITS)	Lectures
1.	Introduction to Law and Policy- basic concept of Law and Policy (Importance and difference)	4
2.	International Conferences impacting Indian legal system such as Stockholm conference, Rio conference, Rio+5, Rio+10.	8
3.	Environmental Policies in the Indian Constitution - Role of constitution in environment protection, Fundamental rights and duties, Article 48A, 51A (g), 58A, etc.	6
4.	Environmental Laws in India • Water Act, 1974 • Air Act, 1981 • Indian Forest Act, 1927/1982 • EPA, 1986 • The Wildlife Act, 1972 • The Biological Diversity Act, 2002 • Others	14
5.	Rules and Regulations (As amended) • Hazardous Waste Rules • Solid Waste Management Rule • Biomedical Waste Rules • Batteries Rules • E- waste rules • Construction and Demolition waste Rules • Concept of Eco sensitive zones, Coastal Regulation Zone • Others	14
6.	National Environmental Policy, Ethical dilemma, Issues of Sustainable Development	6
7.	International Environmental Laws and Policies • UNFCCC, Paris climate accord or Paris climate agreement 2015 • Kyoto Protocol • Convention on Biodiversity	10

	• International Solar Alliance • CITES • Ramsar Convention • Basel Convention • MARPOL • Cartagena Protocol on Bio-safety • AGENDA 21 • Others	
	Reference Books: 1. T S Doabia. 2017. Environmental and Pollution Laws In India. 3rd Edition. Publisher: Lexis Nexis 2. P. Leelakrishnan. 2016. Environmental Law in India. 4th edition. Publisher: Lexis Nexis. 3. S. K. Mohanty. 2009. Environment and Pollution Laws. Publisher: Universal. 4. P. Leelakrishnan. 2006. Environmental Law Case Book. 2nd edition. Publisher: Lexis Nexis. **5.** Divan Shyam and Rosencranz Armin. 2002. Environmental Law and Policy in India: Cases, Material & Statutes. Publisher: Oxford.	

EVSUT-124	WATER & WASTE WATER TECHNOLOGY (4 CREDITS)	Lectures
1	Quantity of water - Water Requirements for domestic consumption. Population forecasting by the following method; Demographic method, Arithmetical progression method, Geometrical progression method, Logistic methods, Graphical projection method, Final prediction. Variation in quantity of water and waste water, Factors affecting rate of demand. Quality of water required for – Domestic, Institutional (Schools, Hostels, Hospitals), Fire fighting, Commercial (Shopping complex, Hotels, Restaurant), Industrial (Dairy, Sugar, Pulp and Paper, etc.). Specific requirement at pilgrimage place and recreation activities Quality parameters for water analysis, methods for analysis	6
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. Packaged drinking water.	5
3	Water Treatment – Principle, Application & Designing of following Unit Operation in water treatment. a. Collection & pumping; b. Aeration; c. Flocculation; d. Sedimentation; e. Filtration; f. Disinfection ; g. water softening	10
4	Advanced treatment methods e.g. a. Demineralization; b. Ultra filtration; c. Reverse osmosis; d. Color & odor removal by activated carbon; e. Iron removal; f. Nitrification and denitrification Selection of appropriate unit operations for the treatment and flow chart of water treatment plant	6
5	Specifications of treated wastewater for disposal into surface water, on land & in marine waters after treatment. Self-purification of water bodies	4
6	Wastewater technology – (Physical, Chemical and Biological Treatment), different models of aerobic and anaerobic digestion by combination of attached & suspended growth Impact of Future growth & development & change in quality of life on sewage quality & quantity.	4

	Role of microorganisms, Kinds of Microorganisms, Pathogenic microbes, indicator microbes, enumeration of microbes, Coliform bacteria as indicator organisms, Tests for the coliform group (MPN Method), growth kinetics. Water borne diseases, Importance of public health perspectives, socioeconomic impacts, Types of waterborne diseases (Protozoan, Algal, Fungal, Bacterial, and Viral diseases), prophylactic measures	
7	Wastewater engineering - Primary, secondary and Tertiary treatment process. Principle and designing of following Unit Operations in waste water treatment: Collection system - Methods of collection, conservancy systems, collection system, water carriage system, sewerage system. Screen chamber, Grit chamber, Oil & grease removal, Aeration and sedimentation, Stabilization pond, Aerated lagoon, Activated sludge process, Trickling filter, Rotating biological contactors Anaerobic digestion processes , fluidized bed reactor, UASB Treatment and Disposal of sludge (composting, sludge cakes, sludge digestion, energy recovery) Special treatments like septic tanks, soak pits.	15
9	Industrial Wastewater-Selection of appropriate unit operations for the treatment and flow chart of wastewater treatment plant for a. Dairy; b. Pulp & Paper; c. Galvanizing, etc.	5
	Reference Books: 1. Waste water engineering – Metcalf & Eddy 2. Elements of Environmental Engineering –K.N. Duggal 3. Water Supply and Sanitary Engineering –G.S.Birdie and J.S.Birdie 4. Water Supply Engineering –Dr. P.N.Modi 5. Water Supply and Wastewater Engineering –Dr. B.S.N.Raju 6. Water Supply Engineering –B.C. Punmia 7. Water Supply Engineering –Hussain 8. Water Supply Engineering –Chatterjee 9. Environmental Biotechnology-T Srinivas (New Age Publications) 10. Environmental Engineering - Peavy, Rowe, Tchenobolus 11. Water supply and sanitary engineering - Rangwala **Books recommended for Practical:** 1. APHA (American Public Health Association) Handbook,1998 2. Soil, Plant and Water Analysis -P. C. Jaiswal 3. Chemical and Biological Analysis of Water -Dr. R. K. Trivedy and P. K.	

	Goel. 4. Practical Biochemistry -J. Jayraman	

EVSUT-125	PRACTICALS RELATED TO EVSC- 121, 122, 123 & 124 (4 Credits)
	EVSUT-121 WATER AND SOIL POLLUTION: MANAGEMENT & MITIGATION 1. Determination of pH, Turbidity & Electrical Conductivity, Solids (TS, TDS, TSS). 2. Determination of Total Alkalinity and Total Hardness of water sample. 3. Determination of Chlorides and Residual Chlorine of water sample. 4. Determination of DO and BOD of given water sample. 5. Determination of COD in given water sample. 6. Determination of Nitrate and nitrites of a water sample. 7. Determination of Sulfates of given water sample. 8. Determination of Phosphates of given water sample. 9. Estimation of oil and grease from a water sample. **Soil Pollution and Control** 1. Determination of pH & Electrical Conductivity, Solids (TS, TDS, TSS).. 2. Determination of Total Alkalinity and Total Hardness of soil sample. 3. Determination of Bulk density and water holding capacity of soil.of given soil sample. 4. To estimate organic carbon of soil sample. 5. To estimate cation exchange capacity of soil. 6. To determine sodium adsorption ratio of soil. 7. Texture Analysis of given soil sample. 8. Estimation of TKN of given soil sample.
	EVSUT – 122 ENVIRONMENTAL POLLUTION II: AIR, NOISE AND RADIATION **Air Pollution:** 1. Determination SOX concentration in air. 2. Determination NOX concentration in air. 3. Determination PM Concentration in air. 4. Determination of heavy metals in collected air samples. **5.** Estimation of Carbon dioxide from air sample. **Noise Pollution:** 1. Measurement of sounds by DB meter / SLM in silent, industrial, residential and commercial zones. 2. Determination of SPL, Lmax, TWA, Leq, Ldn, L10, L50, L90. 3. Determination of Noise dose.
	EVSUT – 123 ENVIRONMENTAL LEGISLATION, ETHICS AND POLICY 1. Field visits and its legal interpretation – submission of detailed reports

	2. Study of case studies and its interpretations - submission of detailed reports
	EVSUT – 124 WATER & WASTE WATER TECHNOLOGY 1. Field visit to river/lake for Sampling procedure, handling and preservation of samples 2. Visit to water treatment plants - Sampling procedure, handling and preservation of samples 3. Visit to wastewater/effluent treatment plants - Sampling procedure, handling and preservation of samples 4. Physico-chemical analysis of waste water to determine quality of sewage and effluent 5. MLSS, SVI study for waste water 6. Jar test for coagulation determination

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