

**Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE**

Syllabus

For

T.Y.B. Sc. (Environmental Science)

(B.Sc. Semester-V and Semester-VI)

**Under CBCS Pattern (2019) Effective from
June 2021**

Deccan Education Society's
Fergusson College (Autonomous), Pune
T.Y.B.Sc. Environmental Science (Pattern 2019)
Under CBCS Pattern (2019) Effective from June 2021

Sem	Paper No.	Course Code	Title	Credits	CE maximum Marks	ESE maximum Marks	Total Maximum Marks
V	DSE-1A	EVS3501	Natural Ecosystems Management	2	50	50	100
	DSE-1B	EVS3502	Environmental Monitoring	2	50	50	100
	DSE-2A	EVS3503	Remote Sensing and GIS	2	50	50	100
	DSE-2B	EVS3504	Environmental Biotechnology	2	50	50	100
	DSE-3A	EVS3505	Introduction to Environmental Statistics	2	50	50	100
	DSE-3B	EVS3506	Climate Change and Sustainability	2	50	50	100
	DSE-1	EVS3507	Environmental Science Practical -I	2	50	50	100
	DSE-2	EVS3508	Environmental Science Practical - II	2	50	50	100
	DSE-3	EVS3509	Environmental Science Practical -III	2	50	50	100
	SEC-1*	EVS3511	Hydroponics: A Green Way of Urban Farming	2	50	50	100
	SEC-2*	EVS3512	Software's in Environmental Studies	2	50	50	100
				Total Credits	22		

VI	DSE-4A	EVS3601	Waste Treatment Technologies	2	50	50	100
	DSE-4B	EVS3602	Wildlife Biology and Conservation	2	50	50	100
	DSE-5A	EVS3603	Environmental Impact Assessment and Management System	2	50	50	100
	DSE-5B	EVS3604	Environmental Governance and Ethics	2	50	50	100
	DSE-6A	EVS3605	Environmental Toxicology, Health and Safety	2	50	50	100
	DSE-6B	EVS3606	Ecosystem Restoration and Remediation	2	50	50	100
	DSE-4	EVS3607	Practical Lab-I	2	50	50	100
	DSE-5	EVS3608	Practical Lab-II	2	50	50	100
	DSE-6	EVS3609	Project	2	50	50	100
	SEC-3*	EVS3611	Entrepreneurship Development & Services by Environmental Consultancy	2	50	50	100
	SEC-4*	EVS3612	Design and Development of Eco- friendly Products	2	50	50	100
				Total Credits	22		

Title of the Course and Course Code	Natural Ecosystems Management EVS3501	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Outline the recognition of an "ecosystem approach" for natural and anthropogenic environments	
CO2	Discuss major pathways by which carbon, nitrogen, phosphorus and water cycle, and energy passes through, ecosystems	
CO3	Apply the skills for ecosystem studies for Research and social awareness.	
CO4	Compare apparently contradictory "taxonomic blindness" versus "taxonomic primacy" embodied within the ecosystem concept.	
CO5	Evaluate the principles of Ecosystem Ecology.	
CO6	Specify the value of various ecosystem states and conditions to human society	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Introduction The Terrestrial Environment, The terrestrial biota and biogeography regions, General structure of terrestrial communities, The soil subsystem, the vegetation subsystem, parameters of the terrestrial environment, Hotspots in India: Western Ghats and Eastern Himalaya.</p> <p>Terrestrial Biomes Introduction, concept, types, Tundra, Northern conifer forests, Temperate deciduous and rain forests, temperate grassland, chaparral, desert, Tropical Rainforest, tropical deciduous forest, tropical scrub forest, tropical grassland and savanna, mountains, Role of Local Government and people in conservation</p> <p>Terrestrial Ecosystem Services and Management Aesthetic and cultural benefits, tourism and recreation, industry, drugs and medicines, carbon pool and sequestration potential, etc. Bio-geocycles as a source of plant nutrients for ecosystem maintenance, Methods of terrestrial ecosystem management: remote sensing geographical information system, Joint Forest Management</p>	18
II	<p>Ecology of Aquatic Ecosystems Elements of structure, functions and processes in fresh- water (lakes and rivers), marine and estuarine ecosystems with respect to hydrology, productivity, and biodiversity, Stratification and zonation in rivers, lakes and oceans with respect to light, temperature, and pressure, Water quality and pollution of lakes, reservoirs, rivers, and marine waters</p>	18

	<p>Aquatic Biomes Lakes and reservoirs: Community organization, productivity, trophic levels and food webs, Bio assessment and bio criteria in lakes and reservoirs, index of biological integrity, Eutrophication and trophic state index; biological adaptations, nutrient dynamics, methanogenesis, Carbon cycle, climate change and impact on lakes and reservoirs, Rivers: Types of rivers, geomorphology, longitudinal profile and classification of drainage network, Rivers and ecological continuum, riparian and floodplain wetlands, River biodiversity, community organization; trophic structure and food webs; energy flow, Structure and function of marine ecosystems, Estuary types and genesis; organisms (plants, animals, microbes) in various ecological zones, community organization, productivity, nutrient cycling and dynamics, upwelling and downwelling of nutrients, mangroves, coral reefs.</p> <p>Aquatic biodiversity, ecosystem services Landscape ecological concepts Coastal regulation zone, International conventions & protocols, Ramsar Convention, Convention on Biological Diversity, Ramsar sites in India, Remote sensing and GIS in aquatic ecosystem management, biodiversity conservation, Climate change and aquatic ecosystem response</p>	
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References:

1. Groom. B. & Jenkins. M. 2000. Global Biodiversity: Earth's Living Resources 21st Century. World Conservation Press, Cambridge, UK, Gurevitch, J., Scheiner, and Fox, G. A. 2002.
2. The Ecology of Plants. Sinauer Associates Incorporated. Loreau, M. & Inchausti, P. 2002.
3. Biodiversity and Ecosystem Functioning: Synthesis and Perspectives. Oxford Univ Press, Oxford, UK, Odum, E. P. 1971.
4. Fundamentals of Ecology. W. B. Saunders, Pandit, M. K., White, S. M. & PM. J. O., 2014.
5. The Contrasting Effects of Genome Size, Chromosome Number and P Level on Plant Invasiveness: A Global Analysis. New Phytologist 203: 697-703. Pimentel, D. (Ed.). 2011.
6. Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal Microbe Species. CRC Press. Singh, J. S., Singh, S. P. & Gupta, S. R. 2006.

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Environmental Monitoring EVS3502	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Recall basic concepts and principles behind various environmental monitoring processes e.g. water, air, soil, noise, biodiversity etc.	
CO2	Summarize definitions of sample, its types etc. Explain various steps and precautions required before sampling of soil, water, air etc.	
CO3	Apply practical skills for analysis of Air, Soil, Noise, and water quality.	
CO4	Identify unknown pollutants from given water, soil, air samples.	
CO5	Evaluate the environmental quality based on its analysis and monitoring.	
CO6	Design the environmental monitoring survey for any ecologically important area and develop methods for sampling and monitoring for it.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Statistics in Environmental Monitoring Concept of sample, types of sampling, Sample support, Sample size & Confidence interval, Frequency Distribution Density Function: Mean, Mode, Median, Variance, Standard Deviation</p> <p>Weather and Air Monitoring Introduction to weather system and parameters, Light, Rainfall, Wind direction, Wind velocity, (Movement of pollutants), Temperature, Pressure, Humidity, Weather Monitoring tools / instruments and their working principle Air sampling: types, techniques, Site and parameter selection, National standards for ambient air quality, Monitoring of particulate matter, SO_x and NO_x, Ambient and stack air monitoring techniques, Air Monitoring tools/instruments used for air its work principle</p> <p>Noise and Radiation Monitoring Introduction of noise & vibration, National standard for noise Sound Exposure Level (SEL), Equivalent Sound Level [Leq(h)] Noise Index, Radiation types and measurement, G. M counter, scintillation counter, personal dosimetry, Units of measurements, Half-life period, and radiation dose measurement.</p>	18
II	Water and Soil Monitoring / Sampling and its Analysis	18

	<p>Objectives of water monitoring, Collection of samples, sample preservation, Physical, chemical, biological parameters of water & its monitoring, General effluent standards, stream standards Drinking water standard (IS10500 and WHO Standards), Objectives of soil monitoring / testing, Types of soil sampling and sample units, Site selection, Important soil quality indicators Instruments / equipment's used in soil monitoring</p> <p>Biodiversity Monitoring</p> <p>Vegetation Monitoring Measurement of height, girth and biomass, Transect method: Line and belt transect, Measurement of frequency, density, abundance and diversity, Shannon index, Simpson Index, IVI</p> <p>Vertebrate Monitoring Point count, pug mark, pellet / dung count, call count, scat / pellet analysis and camera trapping etc.</p> <p>Invertebrate Monitoring Net swipe, light trap, pit traps.</p> <p>Instruments in Environmental Monitoring pH meter, Conductivity meter, Colorimeter, UV Spectrophotometer, Atomic absorption spectrophotometer Flame photometer, Hot air oven, autoclave, laminar flow, RDS, RSPM 2.5, Handy sampler, Gas chromatography, Mass spectroscopy, Scanning electron microscopy</p>	
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References:

1. Handbook of Methods in Environmental Studies: Vol.1 By Maiti, Subodh. (2003).
2. Handbook of Methods in Environmental Studies: Vol 2 (Air, noise, soil and overburden analysis). By Maiti, Subodh. (2003).
3. Waste Water Engineering, Metcalf and Eddy, INC, Tata McGraw Hills
4. Indian Standard for Drinking Water, BSI, New Delhi. Environmental Pollution Control, C. S. Rao, Wiley Eastern Ltd.,1993
5. Air Pollution Control and Engineering, De Nevers, McGraw Hills, 1993, 10.
6. Fundamentals of Air Pollution, Samuel, J. W., 1971, Addison Wesley Publishing
7. Fundamentals of Environmental Pollution, Krishnan Khannan, S. Chand and Company Ltd., 1994.
8. Noise Pollution, Vandana Pandey, Meerut Publishers, 1995.
Environmental Pollution Control, C. S. Rao, Wiley Eastern Ltd., 1993.
9. Air Pollution Control and Engineering, De Nevers, McGraw Hills, 1993.
10. Fundamentals of Environmental Pollution, Krishnan Khannan, S. Chand and Company Ltd., 1994.
11. Environmental Chemistry, A. K. De., New Age Intl. Pub Co, New Delhi, 1990
12. Environmental Pollution Analysis - S. M. Khopkar

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Remote Sensing and GIS EVS3503	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Recall basic concepts, principles and processes that define Remote sensing and GIS. Recall basics of Electromagnetic radiation and Spectrum.	
CO2	Discuss satellites in space, their applications, data acquisition and recent advances.	
CO3	Demonstrate map projection methods to understand its importance and limitations based on method of projection.	
CO4	Compare Raster data and Vector data in GIS to recognize its role in generating information about various features on the earth. Distinguish spatial data and Non-spatial data to understand characteristics and represent the earth features	
CO5	Select classification method, Interpret satellite images visually and digitally. Judge the accuracy level of classified maps.	
CO6	Develop spatial thinking in GIS and use its geo-processes and functions. Apply the understanding to address real life field issues using various softwares.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Fundamentals of Remote Sensing Principles and Process of Remote Sensing, Electromagnetic Radiations (EMR) and Electromagnetic Spectrum, Interaction between Matter and EMR, Types of Remote Sensing Sensors Types of Remote Sensing Platforms, Types of Remote Sensing Systems: Visual Remote Sensing, Optical Remote Sensing, Infrared Remote Sensing, Microwave Remote Sensing</p> <p>Image Analysis Visual Interpretation, Digital Processing: Preprocessing, Image Enhancement, Image Transformation, Image Classification</p> <p>Applications of Remote Sensing in the field of: Agriculture, Forestry, Geology, Hydrology, Sea Ice Land Cover Mapping, Oceans and Coastal.</p>	18
II	<p>Introduction to GIS Definition, Components, Functions and advantages of GIS Process of GIS, Spatial data model and attribute data.</p>	18

	<p>Geospatial Analysis Introduction, Geospatial data analysis methods, Database query Geospatial measurements, Overlay Operations, Network Analysis, Surface Analysis, Geo-visualization</p> <p>Modern Trends of GIS Integration of GIS and Remote Sensing, Integration of GIS and Multimedia, Mobile GIS, Collaborative GIS (CGIS)</p>	
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References:

E-books:

1. Alan S. Belward and Carlos R. Valenzuela (1991) Remote Sensing and Geographical
 2. Information Systems for Resource Management in Developing Countries
 3. M. Anji Reddy (2008) Textbook of Remote Sensing and Geographical Information Systems Third Edition
 4. Norman Kerle Lucas L. F. Janssen Gerrit C. Huurneman Principles of Remote Sensing An Introductory Textbook. ITC Educational Textbook Series. Version of 23rd September 2004.
 5. Fundamentals of Remote Sensing. A Canada Centre for Remote Sensing Remote Sensing Tutorial
- Books:
1. B.Bhatta(2008)Remote Sensing and GIS, Oxford University
 2. Lillesand, T. M. and Keifer, R. W. (1990): Remote Sensing and Image Interpretation, John Willey and Sons, New York.
 3. Joseph G. (2003): Fundamentals of Remote Sensing, Universities Press, Hyderabad.
 4. Haywood, Ian: Geographical Information Systems, Longman.
 5. Chang, Kang-Taung (2002): Introduction to Geographic Information Systems, Tata McGraw-Hill.
 6. Burroughs, P. A. (1986): Principles of Geographical Information Systems for Land Resource Assessment, Oxford University Press.
 7. Gupta, R. P. 2003. Remote Sensing Geology, Springer, New York.
 8. Barrett, E. C. and Curtis, L. F. 1999. Introduction to Environmental Remote Sensing.

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Environmental Biotechnology (RG) EVS3504	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Recall the basic concepts, objectives and scope of Environmental biotechnology and enlist applications of biotechnology in the field of Environment.	
CO2	Explain the terms biopolymers, bioindicators and biosensors. Discuss the role bioindicators and biosensors play in the monitoring of environmental pollutants.	
CO3	Apply the knowledge of biotechnology in the field of agriculture with reference to biopesticides, biofertilizers, composting and vermicomposting.	

	Demonstrate process of phytoremediation and select appropriate method and plants suitable for phytoremediation process.
CO4	Compare methods used for bioleaching and recognize role of microbes in the recovery of metals and oil. Explain the concepts of bioaugmentation and biostimulation. Identify the factors affecting bioremediation process.
CO5	Review the concept, Environmental ethical social and health problems associated with GMO's.
CO6	Prepare a flow chart for production of biopesticides and biofertilizers.

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Environmental Biotechnology Meaning, objectives, need and scope Applications of environmental biotechnology</p> <p>Biotechnology for Sustainable Agriculture</p> <p>Biopesticides Classification of biopesticides, Microbial biopesticides production process, stabilization, formulation, mode of action, Plant Product as biopesticides e.g. Neem pesticides</p> <p>Biofertilizers Types of biofertilizers, Production and role in soil fertility, Agro based solid waste & its use</p> <p>Composting Composting technology and methods of production, Design aspects and factors influencing the process, Temperature trends and influencing factors, Composition and quality of compost</p> <p>Vermicomposting Earthworm life cycle, Operating process, Characteristics of vermicomposting</p> <p>Genetically Modified Organisms (GMOs) GMO's concept, Environmental, ethical, social and health problems associated with GMO's, Biosafety regulations, Cartagena protocol</p>	18
II	<p>Bioremediation</p> <p>Microbial Remediation Process Principles of bioremediation, Concept of bio augmentation and bio stimulation, Factors affecting the bioremediation process: microbial metabolism, environmental conditions and nature of pollutants, Types of Bioremediation</p> <p>Phytoremediation Concept, factors affecting phytoremediation, Plants useful for phytoremediation, removal of metals and organic pollutants Types of phytoremediation: Phytoextraction, Phytostabilization, Rhizofiltration, Phytotransformation, Phytovolatilization, Current developments in the process.</p>	18

	<p>Natural Resource Recovery</p> <p>Oil recovery Microbial Enhanced Oil Recovery (MEOR), Methods used and role of microorganism in MEOR</p> <p>Metal recovery Types of bioleaching, Methods for bioleaching, metal precipitation, Microbes for bioleaching, Advantages and disadvantages of bioleaching</p> <p>Biopolymers, Biosensors and Bioindicators</p> <p>Biopolymers and bioplastics What are biopolymers? Types of biopolymers and its applications</p> <p>Biosensors What is a biosensor? Design and components, Applications of biosensors in environmental monitoring</p> <p>Bioindicators Concept of bio indicators, Plankton community as indicators of water pollution; microbiological quality of potable waters, Microbial indicators organisms, lichens as air pollution indicators.</p>	
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References:

1. Environmental Biotechnology. M. H. Fulekar.
2. Environmental Biotechnology: Basic Concepts and Applications. InduShekhar Thakur, I. K. International Pvt. Ltd.
3. Environmental Biotechnology. Alan Scragg, Oxford University
4. Handbook of Organic Waste Conversion by Bewik M.W.M.

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Introduction to Environmental Statistics EVS3505	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Describe concept of population and sample in Environmental statistics	
CO2	Represent variables in diagrammatic and graphical form.	
CO3	Apply their skills of Environmental statistics and construct various indices.	
CO4	Analyze and compute measures of dispersion with the help of suitable tools.	
CO5	Select suitable dispersion measures and apply it.	
CO6	Generate Environmental datasets and calculate its central component.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Introduction Role of statistics in Environmental research Introduction to concept of Statistics, Population, Sample, Data Concept of univariate, bivariate data, Sampling Types of sampling - Random and non-random</p> <p>Data Presentation Types of data: Discrete and continuous data, Frequency and non-frequency data, Frequency distributions, Sample collection and data presentation methods, Diagrammatic methods, Graphical methods</p> <p>Experiment design Experimental Design and sample collection, Statistical Inference, Hypothesis Testing, p-value, Types of Hypothesis</p>	18
II	<p>Measures of Central Tendency Arithmetic mean, Median, Mode, Geometric mean, Harmonic mean</p> <p>Measures of Dispersion Range, Mean deviation, Variance, Standard deviation, Skewness and Kurtosis</p> <p>Applications Introduction to indices used for various Environmental studies Examples based on ecology and ecosystem, weather and air quality monitoring, soil quality data, water and effluent data, etc.</p>	18

References:

1. Biostatistics by Khan and Khanum
2. Biostatistical Analysis by Zar, Jerrold H., Prentice Hall, (India)
3. Statistics for Environmental Science and Management by Manly Bryan F. J.
4. Statistics for Environment, Vic Barnett, K. Feridun Turkman, Commission of the European Communities, Wiley Publications

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Climate Change and Sustainability EVS3506	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Identify and list environmental, social, and economic impacts of anthropogenic activities and required sustainability framework for mitigation of the same.	
CO2	Classify and distinguish the human induced and natural drivers of climate change. Discuss importance and opportunities for climate change and sustainability development.	

CO3	Examine and interpret environmental impacts for major developmental projects in various societies by using available methodologies and software's.
CO4	Identify the impacts of climate change and compare with future goals of sustainability. Integrate various policies and agreements to examine future outputs regarding sustainability.
CO5	Determine the impacts of climate change and environmental conditions by appropriate tools and techniques. Evaluate the measures for sustainable management of resources.
CO6	Compile the collected data after laboratory methods and surveys to prepare reports about climate change and sustainable practices in society.

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Climatic Systems and Challenges Global Climate System, Internal Variability and External Climate Forces, Evidence and Measurement of Climate changes, Impacts on Life, Vegetation, Fauna, Economics of Climate Change, Climate Change, Water Scarcity, Biodiversity and Food Security</p> <p>Confronting Climate Change: Policies and Efforts National Action Plan on Climate Change (NAPCC), National Adaptation Fund on Climate Change (NAFCC), National Carbonaceous Aerosols Programme (NCAP), UNFCCC and Conference of the Parties, Findings by NASA, ISRO and Special Reports by IPCC, Paris Agreement</p> <p>Mitigation Approaches in Climate Change Climate Change Modeling, Carbon Emissions Reduction Technologies, Governance for Climate Change, Technology Options Fuel Switching and Carbon Sequestration The Economics of Carbon Mitigation: Integrated Assessment Models (IAM), Regional, National and International Experiences</p>	18
II	<p>Sustainable Development Goals and Issues Strategies and Framework for Sustainable Development The 2030 Agenda for Sustainable Development, UN Sustainable Development Knowledge Platform, Sustainable Development Goals, Criticisms in Sustainability: Women and Gender Equality, Education, Public Engagement and Sustainable Development</p> <p>Environmental Conservation and Sustainability Technical Skills in Environment and Sustainability, Environmental Governance and Sustainability, Environmental Economics and Sustainability, Water Conservation and</p>	18

	Sustainable Development, Urbanization and Sustainable Cities, Challenges in Energy, Food, Forest and Agriculture New Developments in Sustainability Appropriate Technology and Sustainability Science, Sustainable Transport, Sustainability Assessment of Food and Agriculture (SAFA), Corporate Sustainability, Sustainability Metrics and Indices, Ecological and Carbon Footprint for Sustainability Measurement, Sustainability Measurement and Reporting Tools, Life Cycle Assessment	
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References:

1. The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming by Roger Pielke, Basic Books (2010)
2. The Climate Solution: India's Climate Change Crisis and What We Can Do About It by MridulaRamesh , Hachette India (2018).
3. This Changes Everything: Capitalism vs. the Climate by Naomi Klein, Penguin (2015).
4. What Is Climate Change? (What Was?) by Gail Herman (Author), Illustrated by John Hinderliter, Penguin Workshop (2018).
5. Climate Change Biodiversity and Green Economy by H.S. Sharma S. Padmaja and Ganesh Sharma, Concept Publishing Company Pvt. Ltd. (2013).
6. Climate Change by Joseph Romm OUP US (2018).
7. Environment and Sustainable Development by M.H. Fulekar, Bhawana Pathak, R K Kale, Springer Nature (2013).
8. Sustainable Development in Digital Era by Dr. Aparna Mishra, Dr. VikasDahiya, Dr. KaminiTandon , JSR Publishing House LLP; (2019).
9. The Age of Sustainable Development by Jeffrey D. Sachs and Ban Ki-moon, Columbia University Press (2015).
10. Target 3 Billion: Innovative Solutions Towards Sustainable Development by APJ Abdul Kalam, Srijan Pal Singh, Penguin India (2011).
11. Management of Resources for Sustainable Development by SushmaGoel, The Orient Blackswan (2016).

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Practicals Based on EVS3501 & EVS3502 EVS3507	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Report the knowledge about coastal ecosystems and benthic fauna.	
CO2	Explain and apply various tools to monitor ecosystem health and services.	
CO2	Demonstrate the methods used for handling and working of monitoring instruments.	
CO4	Analyze the air, water and soil quality using standard methods.	

CO5	Evaluate air and water quality index to rate the air and water quality in the study area.
CO6	Develop ecosystem management plan by involving all stakeholders.

Practicals Based on EVS3501

1. Assessment of values of a wetland
2. Comparative analysis of oligotrophic and eutrophic water bodies by using Indices
3. Study of threat assessment model for an ecosystem
4. Study of soil microflora from root nodules
5. Study of keystone species from a forest region
6. Study of swamp (mangrove) ecosystem of Konkan coast (Visit), Studies on benthic fauna
7. Study of wetland ecosystem (field practical)
8. Estimation of chlorophyll content from given plant material

Practicals Based on EVS3502

1. Air sampling and analysis for PM (SPM, RSPM)
2. Air sampling and analysis for SO_x / NO_x
3. Noise measurement degree of annoyance from selected areas
4. Determination of cation exchange capacity (CEC) of soil
5. Estimation of organic carbon/ organic matter of soil
6. Estimation of water quality index
7. Estimation of sludge volume index
8. Estimation of dissolved oxygen / Free CO₂ from given water sample
9. Estimation and calculation frequency, abundance and density by line / belt transect
10. Estimation of air pollution index

T. Y. B.Sc. Semester V

Title of the Course and Course Code	Practicals Based on EVS3503 & EVS3504 EVS3508	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Outline the phytoremediation techniques and selection of plants useful for remediation.	
CO2	Explain and apply basic techniques for visual image interpretation.	

CO3	Carry out isolation of phosphate solubilizing microbes and test their phosphate solubilization efficiency.
CO4	Analyze remote sensing data digitally using software's.
CO5	Compare and classify the bacteria using Gram Staining technique and recall the mechanism of the staining process.
CO6	Create digital maps using satellite data for any given area.

Practicals Based on EVS3503

1. GPS handling and acquisition of data
2. Georeferencing using toposheet / satellite image / GPS
3. Preparation of subset of satellite image / toposheet
4. Preparation spatial data: Point, line, polygon
5. Visual analysis and interpretation of satellite data
6. Ground truthing: field visit
7. Study of interpolation technique for mapping of ground water quality
8. Study of Google Earth for environmental sciences

Practicals Based on EVS3504

1. Use of microorganisms as bioindicators for water / soil pollution monitoring
 2. Identification and classification of bacteria by Gram staining technique
 3. Preparation of compost by using different methods of composting
 4. Study of vermicomposting techniques for solid waste management.
 5. Qualitative and quantitative estimation of compost and vermicompost.
 6. Study of phytoremediation techniques for removal of pollutants.
 7. Isolation of Phosphate solubilizing microbes and testing of phosphate solubilization efficiency of microbes
 8. Visit to the biotechnology laboratory / research center.
- * Any other relevant practical

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Practicals Based on EVS3505 & EVS3506 EVS3509	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Outline the fundamentals of Environmental Statistics.	

CO2	Explain the data collection, classification and analysis methods. Differentiate between various methods used to estimate environmental parameters.
CO3	Apply the skills for assessment of issues of Environmental science.
CO4	Analyze measures of central tendency and dispersion using software, the relation between resource quality and economics associated with development by using different tests.
CO5	Review and judge the impacts on the local environment in relation with climate change, economics and sustainability and evaluate the impacts by using statistical techniques.
CO6	Collect long term data to prepare final reports with scientific techniques. flowcharts, network diagrams, video documentaries to spread awareness of environmental issues. Formulate maps and final results by using online softwares.

Practicals Based on EVS3505

1. Introduction to functioning of windows and data entry in MS Excel
2. Data presentation by frequency tables, diagrams and graphs.
3. Calculations based on measures of central tendency
4. Calculations based on measures of dispersion
5. Calculations based on relative measure of dispersion
6. Calculations based on measures of skewness and kurtosis
7. Introduction to software used for basic statistical analysis
8. Applications of statistics for Ecology, Climatology, Water and Soil quality, etc.

Practicals Based on EVS3506

1. Estimation of carbon sequestration by using different methods
2. Impacts of extreme events in selected areas: A case study
3. Preparation of documentary on climate change and sustainability practices of an organization or agency or village area
4. Studies on measurements of sustainable farming practices
5. Questionnaire survey on climate change/sustainability based on online platforms and analysis
6. Measurement of carbon footprint and ecological footprints by using online software
7. Study of HYSPLIT Backward and Forward Trajectory Model to know Origin and Final Places of Air Masses
8. Use of ARCGIS software for water/soil quality mapping
9. Use of OpenLCA software with case study as a sustainability measurement tool
10. Application of CropWat (FAO) software for crop water requirements and irrigation requirements based on soil, climate and crop data
11. Preparation of sustainability report: Study of MNC

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Hydroponics: A Green Way of Urban Farming EVS3511	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the fundamentals of hydroponics.	
CO2	Discuss the role and responsibilities of various institutions.	
CO3	Apply their skills of use of different media for hydroponics techniques.	
CO4	Explain the principles of watershed hydroponics techniques.	
CO5	Test and apply their skills of hydroponics for Research and social awareness.	
CO6	Specify about policies and legislation on safety in industries and workplace environments.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Concept of Hydroponics A brief history of Hydroponics, Current research, Hydroponics mediums: Coconut Coir Perlite. LECA. Perfect Starts. Rockwool, Hydroponic Technology: Sand and Gravel Culture. The Dutch Bucket Method. The Rockwool Slab Drip System. The Nutrient Film Technique (NFT). The Raft System. EinGedi System. Aeroponics. The Autopot. Vertical Gardening, Plant Nutrition: The Organic Composition of Plants. Macronutrients. Micro Nutrients. Selecting A Hydroponic Nutrient. Making Your Own Nutrients. Maintaining Nutrient Concentration And pH. Nutrient Solution Microbiology. Supercharge Your Garden with CO₂. CO₂ and You. Do-It-Yourself CO₂, Light Requirements: High Intensity Discharge (HID) Lighting. Intensity. Duration (Photoperiod): Color (Photosynthetic spectrum). Choosing A Grow Light.</p>	18
II	<p>Applications of Hydroponics Hydroponics as a Commercial activity, Establishing a Market for Your Garden, Investigate Your Local Market, Product Quality Considerations for project, Approaching Prospective Customers, Hydroponics -applications and customization under Indian conditions</p>	18

References:

1. Greenhouse Technology –Arupratan Ghosh
2. Handbook of Saline and alkali soils -USDA
3. Vegetable Production in India- D.V.S.Chauhan
4. Vegetable growing in India – P.S. Arya and Santprakash

5. Vegetable growing – Choudhary
6. Horticulture at glance- Amarsingh
7. Plant Propagation – Hertman et al
8. Preservation of fruits and Vegetables -Girdharilal and Tondon
9. Principles of fruit growing – Yawalkar and Kunte
10. Foods and Nutrition – SumatiMudambi
11. Plant Physiology- Pandey and Sinha
12. Plant physiology –Jain
13. Hand book of Agriculture –ICAR Publications
14. How to Hydroponics-by Keith Roberto

T. Y. B.Sc. Semester V		
Title of the Course and Course Code	Softwares in Environmental Studies EVS3512	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Identify and list different software used in environmental studies.	
CO2	Outline and apply statistical skills for environmental studies.	
CO3	Calculate parameters of environmental significance by using software	
CO4	Analyse environmental monitoring data with the help of various tools	
CO5	Determine the importance of Environmental variables.	
CO6	Collect data, compute and compare obtained results by using different software.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	Open-Source GIS Data Acquisition Satellite Images, DEMs, Topo Maps Use of Bhuvan Portal for GIS Studies Open-source Software's in the field of Remote Sensing and GIS Image Processing Software's, GIS Software's Climate Change/Carbon Emission Measurements	18

	Processing of Video by Mobile Apps, Chroma Key Effect Online Carbon Sequestration Calculators, WWF Footprint Calculator, Online Carbon, Water and Ecological Footprint Calculators, ICAO Carbon Emissions Calculator, USEPA Carbon Footprint Calculator, Use of ARCGIS software for Climate Change/Water/Soil Quality Mapping, UN carbon footprint calculator, Study of HYSPLIT Backward and Forward Trajectory Model, Use of Online Platforms for Surveys and Analysis of Data, Requirements for Android App Development for Climate Change/Environmental Parameters	
II	Experimental Designing for Environmental Monitoring Introduction, Tools used for experiment design and sampling Software's used for visual interpretation Introduction to software's used for visual interpretation Diagrammatic presentation, Graphical presentation Software's used for data analysis Introduction to functions of Excel, PAST and other open sources tools for data analysis and interpretation Sustainability Measurement Software +*-Use of Open LCA Software for Different Case studies Study/Demo Version of Software (SimaPro, GaBi) used in Life Cycle Assessment, Use of CropWat (FAO) software crop water requirements, Study of DSSAT as a Sustainability Tool, Demo on ESG: Sustainability Management Software, Tutorial on Cool Farm Tool.	18

References:

<https://past.en.lo4d.com/windows>
<https://www.microsoft.com/en-in/download/details.aspx?id=7120>
<https://www.ibm.com/analytics/spss-trials>
https://bhuvan.nrsc.gov.in/bhuvan_links.php
<https://earthexplorer.usgs.gov/>

<https://offset.climateutralnow.org>
<https://footprint.wwf.org.uk>
<https://www.icao.int>
<https://www3.epa.gov>
<https://www.ready.noaa.gov>

<https://www.openlca.org/>
<https://simapro.com/>
<http://www.gabi-software.com/>
<http://www.fao.org/land-water/databases-and-software/climwat-for-cropwat/en/>
<https://dssat.net/>
<https://www.gensuite.com/products-and-services/sustainability-management-software/>
<https://coolfarmtool.org/>

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Waste Treatment Technology EVS3601	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Outline key terms used in waste management and control of pollution.	
CO2	Explain working principles and concepts of various treatment methods and their outcomes.	
CO3	Examine practical skills for treatment of different wastes.	
CO4	Analyze and select various treatment methods for wastes.	
CO5	Evaluate the working of various treatment technologies and performance.	
CO6	Develop the methods for eco-friendly management and control of various environmental pollutants.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Solid, Biomedical and Hazardous Waste Sources and generation of waste, Characterization of waste Concept of resource recovery from waste: Refuse derived fuel (RDF), vermicomposting, Different WTE processes: Combustion, pyrolysis, landfill gas (LFG) recovery, anaerobic digestion, gasification</p> <p>Air Treatment Control of air pollution by fuel selection, Principle and working of: Cyclones, Scrubbers, Settling Chambers, Fabric Filters and Electrostatic Precipitators, Control of gaseous pollutants by absorption, adsorption, condensation, vapor incineration</p> <p>Water Treatment Flow chart for wastewater treatment plant, Selection of appropriate unit operations for the treatment: Primary treatment, Secondary treatment (Biological): Aerobic and anaerobic methods, Tertiary treatment, Advance wastewater treatment processes.</p>	18
II	<p>Noise Control: At source: Sound path receiver concept, control by design Noise control in the transmission path: Acoustical separation, physical barriers, Isolators and Silencers, Protecting the receiver: personal protection devices</p> <p>Land / Soil Treatment: Physical / Mechanical Methods:</p>	18

	<p>Contour trenches, continuous contour benches, live hedges, Ex-situ-Heavy metal immobilization through vitrification, In-situ - appropriate cultivation practices, soil vapour extraction.</p> <p>Chemical Methods: Ex-situ - acid leaching, In-situ - pH correction</p> <p>Biological Methods: biofertilizers & biopesticides, mixed cropping, crop rotation, biological pest management., organic farming, Bio / Phytoremediation of contaminated</p> <p>Nuclear and Radioactive Waste: Generation of waste from various sources, Classification of radio-active wastes - gas, solid, liquid, Control measures - treatment and disposal of radio-active waste, ICRP recommendations, Protection to workers, Case studies: Three Miles and Chernobyl accidents.</p>	
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References:

- 1) Soil and Water Conservation Engineering by R. Suresh - Standard Publishers and Distributors. ISBN 8180140008
- 2) Land and Soil Monitoring: A Guide for SoE and Regional Council Reporting; New Zealand published by the Land Monitoring Forum, New Zealand. 2009
- 3) Nuclear Energy - Principles, Practice and Prospects: S. K. Agarwal; APH Publishing Corporation.
- 4) Bio-Energy Resources: P. Chaturvedi, Concept Publishing Company.
- 5) Destruction of Hazards Chemicals in the Laboratory: G. Lunn and E. B. Sansone.
- 6) Environmental Chemistry: M. Satake, Do, S. Sethi, S. A. Eqbal.
- 7) Waste Water Engineering, MetCalf & Eddy; Inc, Tata McGraw Hill.
- 8) Waste Water Treatment for Pollution Control, Dr. Arceivala, Tata McGraw Hill.
- 9) Source Book on Atomic Energy - S. Glasstone, D. Van Nastrand & Germany.
- 10) Environmental Radioactivity - M. Eisenbud, Academic Press
- 11) Essentials of Nuclear Chemistry - II, T. Arnika, Wiley Easter.
- 12) Nuclear Chemistry Through Problems - II, T. Arnika & N. S. Rajurkar, New Age Int. (P) Ltd.

Title of the Course and Course Code	Wildlife Biology and Conservation EVS3602	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Recall definition and concepts in Wildlife Biology.	
CO2	Distinguish groups of plants and animals and Summarise their habitats	
CO3	Apply field survey techniques for wildlife survey	
CO4	Identify the various threats to wildlife.	
CO5	Rank the threats and determine conservation measures.	
CO6	Design the wildlife survey for any ecologically important area and develop local conservation plan.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Basics of Wildlife Biology Introduction, Concept of Wildlife Biology, Definition of Wildlife (Refer to Wildlife Protection Act), Examples of protected wildlife species</p> <p>Wildlife Classification and Habitats Diversity of major groups of plants and animals: Plants, Algae, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms, (Monocots and Dicots), Animals, Invertebrates -Arthropods (Insects, Arachnids, Crustaceans, Millipedes, Centipedes). Vertebrates- Mammals, Birds, Fish, Reptiles, Amphibians, Habitats of Wildlife: Aquatic and Terrestrial</p> <p>Threats to Wildlife Habitat destruction, Developmental projects, Urbanization Agricultural expansions, Excessive harvesting and Poaching Human-wildlife conflict, Examples of excessive exploitation of plants and animals.</p>	18
II	<p>Concept of Conservation Concept of Nature Conservation, CBD, PAN</p>	18

	<p>Conservation approaches: Species, habitat, ecosystem, Objectives and challenges of nature conservation, In-situ and Ex-situ conservation</p> <p>Wildlife Assessment</p> <p>Population assessment techniques for flying insects Birds and Mammals:</p> <p>Net swipes, Transects, Point counts, Census from pug marks, Camera trapping, Diversity assessment for plants, Determination of sampling area, quadrates, transects, point Centre method, Diversity indices and its applications, Application of GIS and remote sensing (Radio tagging) in monitoring of wildlife and wildlife planning and management</p> <p>Efforts for Conservation</p> <p>Role of IUCN, WWF and other large organizations, Role of governments, International conventions and protocols, Role of NGOs, Greenpeace, International Whaling Mission, BNHS, Reindeers, Project Tiger, Crocodile Farms, Examples of extreme activism and practical sustainable efforts</p>	
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References:

- 1) Anthony R.E. Sinclair, John M. Fryxell and Graeme Caughly (2006) Wildlife Ecology, Conservation and Management. Blackwell Publishing, U.S.A.
- 2) Odum E. P. (1971): Fundamentals of Ecology.
- 3) Singh J. S., Singh S.P. & Gupta S. R. (2006): Ecology, Environment and Resource Conservation. Anamaya Publications.
- 4) Wilson E. O. (1985): The Biological Diversity Crisis. BioScience35: 700-706.
- 5) Negi, S.S.: Manual for Wildlife Management in India.
- 6) Sinha, P.C. (1998): Wildlife and Forest Conservation. Anmol Publishing Pvt. Ltd., New Delhi

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Environment Impact Assessment and Management EVS3603	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	State the scope, importance and opportunities in EIA practices in relation with sustainable development	

CO2	Illustrate and study methods for impact assessment and prediction
CO3	Examine standard practices of management and development of standards.
CO4	Explain important guidelines of Environmental management system standards
CO5	Evaluate Environment Management plan and mitigation measures
CO6	Perform Environmental Audit by applying skills.

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>EIA EIA: Scope and Objectives, EIA and sustainable development EIA Notification 1994 & 2006, Components and Process Baseline Data</p> <p>Methods Ad Hoc Method, Checklists, Matrices Networks, Simulation Modelling, Overlays and Geographic Information Systems</p> <p>EMP Significant Impacts and Mitigation, Mitigation Plans, Relief & Rehabilitation, Risk Assessment and Disaster Management Plan Review of Environmental Management Plan, Draft of EIA report</p>	18
II	<p>EMS Introduction to Environment management systems, Organization's approach to the Environment, Environmental and economic sustainability, Concept of EMAS and EMS standards and tools, Projecting EMS: planning, implementation, general requirements, control tasks, Evaluation of Environmental performance</p> <p>ISO 14001:2015 ISO governance, structure and functions, PDCA cycle, ISO 14000 family of standards, Introduction to ISO 14001:2015: Guidelines for implementation of standard</p> <p>Environmental Audit Requirement of Rule 14, Environment (Protection) Act, 1986 Environmental Audit: Need & Importance, Process of Environmental Audit, Types of Audit</p>	18

References:

1. Barrow, C. J. 2000. Social Impact Assessment: An Introduction. Oxford University Press.
2. Judith, P. 1999. Handbook of Environmental Impact Assessment. Blackwell Science.
3. Tinsley, S., & Pillai, I. (2012). Environmental management systems: understanding

organizational drivers and barriers. Taylor & Francis.

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Environmental Governance and Ethics EVS3604	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Recall basic concepts and principles in relation with environmental governance, ethics and policies. Identify the relation between good governance and ethics.	
CO2	Explain the important provisions of environmental laws. Discuss the differentiation in policies and implementation ways of various societies.	
CO3	Examine legal case studies from Indian and other societies. Interpret the judgments given as part of various laws.	
CO4	Compare ethical and legal practices followed in various societies. Identify hurdles in effective implementation of environmental governance and ideal ethics.	
CO5	Review international practices in relation with effective implementation of laws. Decide the better options of governance as per changing needs of the society.	
CO6	Collect primary and secondary data to prepare reports based on various judgments. Design questionnaires and carry out surveys in relation with laws and ethics.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Constitutional Provisions and National Policies Constitutional Provisions for Environmental Protection National Environmental Policy, National Forest Policy, Ecomark Scheme, National Conservation Strategy and Policy Statement, Public Interest Litigation</p> <p>Anti-pollution Acts with Important Amendments The Air (Prevention and Control of Pollution) Act, 1981, The Water (Prevention and Control of Pollution) Act, 1974 Environment (Protection) Act, 1986, The Motor Vehicles Act, 1988, The Public Liability Insurance Act, 1991, The National Environment Tribunal Act, 1995, Factories Act, 1948 & the Occupational Safety, Health and Working Conditions Code, 2020</p>	18

	<p>Anti-pollution Rules The Noise Pollution (Regulation and Control) Rules, 2000 E-waste (Management) Rules, 2016, Plastic Waste Management Rules, 2016, Hazardous Waste Management Rules, 2016, Bio-Medical Waste Management Rules, 2016, Solid Waste Management Rules 2016</p>	
II	<p>Environmental Conservation Acts with Important Amendments The Wild Life (Protection) Act, 1972, Biological Diversity Act, 2000 Environmental Ethics and India², Forest (Conservation) Act, 1980, Prevention of Cruelty to Animals Act, 1960, Protection of Plant Varieties and Farmers' Rights Act, 2001 Regulatory framework for Genetically Engineered Plants in India</p> <p>Environmental Ethics and India Origin of Environmental Ethics, Value Education, Ethical Theories Applied to Environment, Role of Indian Culture in Development of Ethics, Environmental Ethics and Policies in India, Development and Ethical Issues in India</p> <p>World Environmental Ethics Earth Ethics and Business Ethics, Role of Western Philosophers in Development of Ethics, Religions and Environmental Ethics, Role of Ethics in Contemporary World Ethics and Sustainability, Challenges of World Environmental Ethics</p>	18

References:

1. P. Leelakrishnan: Environmental Law in India, Lexisnexis, 2010.
2. Alexander Gillespie: International Environmental Law, Policy and Ethics. Oxford University Press, 2014.
3. Divan Shyam and Armin Rosencranz: Environmental Law and Policy in India, Oxford University Press, 2002.
4. P. B. Sahasranaman: Handbook of Environmental Laws, Oxford University Press, 2012.
5. Surendra Malik and Sudeep Malik: Supreme Court on Environmental Law, Eastern Book Company, 2015.
6. Nawneet Vibhaw: Environmental Law - An Introduction, Lexisnexis, 2016.
7. Nancy K. Kubasek and Gary S. Silverman: Environmental Law, Pearson, 1999.

8. Guha R.: Environmentalism: A Global History, Allen Lane 2014.
9. Paul Pojman and Louis Pojman: Environmental Ethics, Wadsworth Publishing, 2011.
10. Joseph R. DesJardins, Environmental Ethics: An Introduction to Environmental Philosophy, Wadsworth Publishing, 2005.
11. Santra S. C.: Environmental Science by New Central Book Agency (P) Limited, 2001.

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Environmental Toxicology, Health and Safety EVS3605	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall the concept of Environmental toxicology and basic parameters of toxicity testing. Discuss toxic effects of Volatile and organic solvents, heavy metals and other toxicants.	
CO2	Explain concepts of epidemiology investigate potential and widespread effects of water and airborne diseases	
CO3	Demonstrate Various toxicity tests with suitable examples and compare toxicity of various toxicants based on toxicity parameters. Apply the skills of epidemiological studies for research and social awareness.	
CO4	Differentiate between bacterial and viral diseases and relate causative agents based	
CO5	Evaluate potential and extent of spread and effects of epidemic and pandemic diseases.	
CO6	Specify occupational health hazards and safety measures, laws and regulations for handling / disposal of toxic materials.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Introduction to Environmental Toxicology Concept of environmental toxicology, toxicants and xenobiotic Systemic toxic effects: acute toxicity, sub chronic toxicity, chronic toxicity, Factors determining adverse effects: Intrinsic toxicity, dose, exposure conditions, response of host, Biomagnification and Biotransformation of toxicants</p> <p>Toxic Effects Parameters of toxicity testing: Effective Doses (EDs), No Observed Adverse Effect Level (NOEL), LC50 LD50 etc.</p>	18

	<p>Mixed exposures effects: Additive effects, Synergistic effects, antagonistic effects, Mutagenic, teratogenic, carcinogenic effects, Toxicity test: Range finding, screening, definitive toxicity test, Direct and indirect effects of stressful environments on human health</p> <p>Water and Airborne Diseases</p> <p>Concept of epidemiology, Endemic, epidemic and pandemic diseases, Waterborne bacterial and viral diseases: Causative agents, spread of disease symptoms prevention and control measures, case studies, Airborne bacterial and viral diseases: Causative agents, spread of disease symptoms prevention and control measures, case studies, Bioterrorism and protective measures.</p>	
<p>II</p>	<p>Occupational Health and Safety</p> <p>Concept of hazard, risk and safety, Objectives and principles of OHS, Elements of the work environment, Occupational hazards: Types, Occupational disorders, Occupational health hazards in industries, case studies, Risk assessment, Introduction to ISO 45001:2018 Occupational Health and Safety Management Systems Standard</p> <p>Industrial and Environmental Toxicants</p> <p>Classification of toxic materials, Industrial toxicants and hazardous materials, Physiological and metabolic effects of toxicants, Toxicity of VOC used in industry, Metal Toxicity: Hg, Pb, As, Cd etc. Nonmetal toxicity: Nitrate-Nitrite poisoning, Fluorosis etc. Plant toxins, zoo toxicity, microbial toxicity, Radiation hazards: Biological effects.</p> <p>Toxicology and Law</p> <p>Regulatory agencies, Factories Act,1948, Hazardous waste rules,2008, Hazardous and other waste rules, 2016, The Occupational Safety, Health and Working Condition, Code, 2020</p>	<p>18</p>

References:

1. Environmental Studies: D. K. Asthana and Meera Asthana, S. Chand Publication
2. Industrial Safety and Environment (2013): Anupama Prashar, S. K. Kataria & Sons.
3. Introduction to Toxicology, Children's Health and the Environment, CHEST Training Package for the Health Sector.
4. Essentials of Toxicology: Vijay Kumar Matham
5. Occupational Health and Safety, Ethiopia Public Health Training Initiative, August 2006

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T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Ecosystem Restoration EVS3606	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	State key ecological principles used for restoration of terrestrial and aquatic ecosystems.	
CO2	Discuss about the role of conservation and restoration play within the larger context of natural resource management.	
CO3	Apply their skills for ecosystem restoration for Research and social awareness.	
CO4	Explain about restoration approaches that require careful assessment of alternatives constrained by complex ecological, sociological and political realities.	
CO5	Evaluate the principles of Restoration Ecology.	
CO6	Specify the value of various ecosystems which have been improved after restoration practices.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Restoration Ecology Eco Restoration, Definition and principles, Significances, Guidelines, Principles of Restoration, Applications of Restoration Ecology</p> <p>Theoretical basis for understanding restoration potential Concepts of resilience and ecosystem change as they relate to aquatic and terrestrial systems, Social, economic and political realities of restoration</p> <p>Restoration of Urban Ecosystem Ponds, lakes, river banks, avenue tree, Biodiversity restoration through gardens, park, restoration of dumping ground,</p>	18

	Restoration of ecosystem on hills, Restoration of soil in urban areas, Ground water resource – replenishment, Sewage or wastewater - recycling for supporting ecosystems Case studies	
II	Eco-restoration and Industrial Environment Eco-restoration of mines (Open-cast), restoration of solid waste dumping sites, Improving aesthetics by partial restoration at industrial sites, Case studies Restoration of other Natural Habitats / Ecosystems Mangroves, Grasslands, Wetlands, Restoration of streams Degraded forest patches, Coastal ecosystems, Case Studies Restoration Toolbox Terrestrial techniques (fire, mechanical, chemical and rest) Aquatic techniques (geomorphic structures, hydrologic regimes, riparian structures and processes), analysis of trajectories of past and future change, Landscape level issues associated with endangered species, Re-colonization of animal, Prevention of habitat loss, Species-area relationships	18

References:

1. Restoration of Nature by Prakash Gole.
2. Restoration Ecology the New Frontier - Edited by Jelte Van Andel and James Aronso Wiley-Blackwell Publication, ISBN9781444336368.
3. A Source Book for Ecological Restoration by Foundation for Ecological Security, 2008.
4. Foundations of Restoration Ecology (The Science and Practice of Ecological Restoration Series) - Donald A. Falk, Margaret Palmer, Joy Zedler, Richard J. Hobbs.
5. Watershed Manual by B. K. Kakade (BAIF and LEAD India Publication).
6. Water Harvesting and Sustainable Supply in India by R. N. Athavale Centre for Environment Education, ISBN: 8170337526.
7. Watershed Hydrology by Peter Black, Lewis Publishers, ISBN1575040271.
8. Soil and Water Conservation Engineering by R. Suresh - Standard Publishers and Distributors, ISBN8180140008

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Practicals Based on EVS3601, EVS3602 & EVS 3603 EVS3607	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Identify the threats to wildlife and the role of local people in conservation.	
CO2	Explain the methods used for Impact identification and assessment.	
CO3	Apply skills based on Environmental Impact and Management Plan. Calculate diversity indices and carry out quantitative assessment of plants and animal groups. Demonstrate the anaerobic digestion process.	
CO4	Analyze the wastewater and solid waste to assess the extent of pollution level.	
CO5	Evaluate the noise level and specify the noise quality. Select a dose of coagulant for wastewater treatment.	
CO6	Design and draw the outline of wastewater treatment plants.	

Practical's Based on EVS3601

1. Characterization of domestic/municipal/college waste.
2. Treatment of biological waste by anaerobic digestion.
3. Design of ETP / STP by using given data.
4. Measurement of equivalent noise level by SLM from silent, industrial, residential and commercial zones.
5. Estimation of chemical oxygen demand from given waste water sample.
6. Estimation of biological oxygen demand from given waste water sample.
7. Study of a jar test for wastewater treatment.
8. Visit to hazardous waste/biomedical waste treatment facility/ ETP/ STP.

Based on EVS3602

1. Types of sampling for ecological studies
2. Study of flora of an urban terrestrial ecosystem (Field practical)
3. Study of fauna of an urban terrestrial ecosystem (Field practical)
4. Vegetation analysis by Quadrant / Belt transect method.
5. Assessment of birds / mammals by transect method.
6. Assessment of the diversity within an ecosystem using Shannon and Simpson's diversity indices.

7. Assessment of threats to wildlife and their habitat in Western Ghats (Field visit)
8. Assessment of people's knowledge and awareness about wildlife.
9. To study the role of local people / visitors in conservation.

Practical's Based on EVS3603

1. Study of requirements of EIA notifications.
2. Study of EIA process with suitable examples.
3. Case studies based on impact assessment and prediction methodologies.
4. Evaluation of EIA by using Leopold Matrix technique.
5. Preparation of draft of EIA report on selected developmental project.
6. Questionnaire based survey for Environmental and socioeconomic survey.
7. Discussion on EIA case studies.
8. Preparation of EMP.

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Practicals Based on EVS3604, EVS3605 & EVS3606 EVS3608	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Identify and describe applications of Environmental Governance and Ethics	
CO2	Discuss and interpret various judgements on selected environmental laws	
CO3	Examine the effect of toxicants on plants and aquatic organisms and evaluate the dose of toxicant.	
CO4	Interpret the effect of metals and metal salts on microbes. Analyse the risk based on health and safety aspects.	
CO5	Determine the amount of coal burnt for household energy requirement.	
CO6	Create a plan for a city to conserve energy on the basis of energy consumption pattern	

Practicals Based on EVS3604

1. Survey on field conditions and drawbacks associated with selected environmental law
2. Law specific case study on violation in selected area
3. Understanding process of public interest litigation through court

4. Preparation of report on major judgements by courts on selected law a) Kani Tribe Case Study b) Divya Pharmacy Case Study c) Taj Trapezium Case
5. Report preparation on understanding the process of filing environmental case
6. Legal survey based on questionnaire to understand environmental governance
7. Study of consents required under water and air act
8. Study of authorizations required under various rules of environment act
9. Understanding Comprehensive Environment Pollution Index and categorisation of the industries
10. Study of user Manual for new users to register on MPCB portal & apply for Consent Service
11. Detailed study of SPCB/CPCB/MoEFCC websites for ongoing programmes and legal requirements for environmental conservation

Practicals Based on EVS3605

1. Assessment of risk using different techniques.
2. Determination of MPN from drinking water resource for potability
3. Effect of toxicants / wastewater on seed germination
4. Estimation of effect of toxicant /metal / industrial effluent on aquatic organisms
5. Estimation of protein / proline from given plant / animal tissue sample
6. Study of oligodynamic effects of metals sheets / metal salts on microorganisms
7. Visit to toxicity testing laboratory / research center
8. Estimation of polyphenol content from plants exposed to pollution

Practicals Based on EVS3606

1. Study of wind data analysis for installation of windmills
2. Study of luminance by Lux meter
3. Estimation of solar radiation by using Sunshine Recorder
4. Preparation of fuel pellets from organic waste collected from college campus / residential area / garden waste etc.
5. Bioelectricity production from organic wastes collected from college campus / residential area / garden waste etc.
6. Design and development of solar powered battery/Study of electric storage system - battery
7. Study of applications of solar energy e.g. solar cooker and water heater / photovoltaic cells.
8. Estimation of calorific value from given biomass samples
9. Study of energy audit process: Formats and Survey
10. Visit to the energy park.
11. Visit to nuclear power plant / nuclear energy research center, BARC, Mumbai, Jaitapur etc.
12. Visit to biogas / biogasifiers / biodiesel plant

Title of the Course and Course Code	Project Work EVS3609	Number of Credits :2
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe purpose of the selected topic of the project work. List basic concepts in scientific work.	
CO2	Discuss basic concepts in research to implement the project work. Associate the objectives in relation with selected topics of research. Outline effective timeline for implementation of research ways.	
CO3	Carry out step by step implementation of methodology for completion of selected objectives within the decided time frame. Apply practical skills for analysis of various parameters.	
CO4	Analyse the various parameters by using standard sophisticated instrumentation techniques and well known methods. Identify the issues and work towards solutions.	
CO5	Assess the impacts or evaluate the basics behind the selected topic of interest. Evaluate the scientific and field related work to recommend certain steps to be implemented by agencies.	
CO6	Collect and compile data to form a final report based on scientific understanding. Write as per international acceptability. Prepare an ideal report with standard guidelines.	

Policy Followed for T. Y. B. Sc. Project Work and Submission

Students have to complete six monthly project reports for successful completion of B. Sc. degree. Students can select topics related with various areas of environmental science. Initially students are asked to submit brief synopsis of the proposed work. Allotment of supervisor and final topics are selected based on facilities available in the department and based on possibilities of scientific work. Students are also free to have collaborative work and can choose a supervisor outside college. It is advised that students should have combination of external and internal supervisor after consultation with departmental staff member. Students can also start their project work at the start of year. An innovative topic, problem solving approach and originality in the work is expected.

Students can select experienced teachers / experts / scientists of other reputed institutions. 'Acceptance Certificate' is required from external supervisor. Exposure and collaborative work is highly encouraged. Strict internal evaluation is carried out through six months while for final presentation and assessment of submitted reports, external supervisors are invited. The final report is prepared as per standard format which includes 'Completion Certificate' and 'Declaration' regarding originality of the content and work done by the student.

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Entrepreneurship Development and Services by Environmental Consultancy EVS3611	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Identify and outline various requirements for development of environmental consultancy/startup	
CO2	Discuss guidelines available for development of a laboratory. Explain compliance requirements under environmental laws and rules.	
CO3	Examine different water and wastewater treatment/air pollution control technologies.	
CO4	Organize and explain guidelines/formats under EIA and EHS.	
CO5	Evaluate and review important services provided by environmental consultants/NGOs	
CO6	Prepare documentation on detailed requirements for establishment of NGO and individual startup.	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p>Introduction Scope for Business Development in India in 21st Century Most Popular Business Types and Requirements for Formation, Need for Government/Professional/Licenses& Collaborations, Understanding Psychology of Sustainability and Circular Economy as a Consultant Current Projects and Thrust Area of CPCB/MPCB Patents for Business Development, Copyrights and Logos for Consultancies</p> <p>Development of Laboratory and Training Centre Guidelines for Recognition of Environmental Laboratories under the Environment (Protection) Act, 1986, Guidelines for Recognition as NABL Accredited Laboratory, Importance of Training Centre.</p> <p>Compliance Requirements by MPCB/CPCB Detailed study of SPCB/CPCB/MoEFCC websites Registration with MPCB and Application for Consent Service (MAITRI Portal), Consents under Water and Air Act, Authorization's Required under Rules of Environment Act, CEPI and Categorization of the Industries, Environmental Statement (Form V)</p>	18

	<p>Water and Wastewater Treatment/Air Pollution Control</p> <p>Design and Development of STP/ETP, Treatment and Maintenance Services, Phytoremediation and Patents</p> <p>Supply of Equipment's and Installation of Air Pollution Control Devices</p>	
II	<p>EIA Services</p> <p>Current Notifications with Amendments, Software's Used in EIA practices, Formats and Documentation Required</p> <p>Functional Areas Expert: Qualifications and Approval Requirements for Accreditation as EIA consultant</p> <p>EHS Related Services</p> <p>Popular ISO Standards, Workplace Monitoring</p> <p>Safety Report, Safety Manual, Safety Policy and Occupational Health Impact, Job Safety Analysis, Health Impact Assessment, HAZOP Study, Preparation of Sustainability Reports, Safety Audit Format: IS 14489 (1998)</p> <p>Other Important Services Provided by Consultants</p> <p>Remote Sensing and GIS Mapping Services, Energy Conservation Services, Restoration of Lands/Water bodies, Organic Farming and Green Belt Development</p> <p>Preparation of EMS Reports, Ecomark Scheme and Requirement, Green Building Certifications: LEED, WELL Buildings, IGBC, TERI Griha, Life Cycle Assessment Reports, Ecological and Carbon Footprints</p> <p>Biodiversity Management, Rainwater Harvesting</p> <p>Solid and Hazardous Waste Management, Trainer, Writer, Webinar Expert, Personal Expert, Development of Climate Change Mitigation Plans, Training on Sustainable Agricultural Practices, Requirements for Sustainable Smart Cities</p> <p>Establishment of an NGO</p> <p>Cause and Mission of NGO, Board of directors/members and name of your NGO, Memorandum Articles of incorporation/ Articles of Association</p> <p>NGO registration, Fund's collection, Building a wide network</p> <p>Individual Start up in the field of Environment</p> <p>Sole Proprietorship/Freelance:</p> <p>Minimum requirements and Registration,</p> <p>OPC (One Person Company):</p> <p>The Companies Act, 2013, Section 2(62), Section 3(1)(c)</p> <p>Sole Proprietorship vs OPC</p>	18

References:

<https://cpcb.nic.in/>

<https://mpcb.gov.in/node>

<http://moef.gov.in/>

<https://lawmin.gov.in/>

<https://nabet.qci.org.in/>

<https://nabl-india.org/>

<https://bis.gov.in/>

<http://www.mca.gov.in>

T. Y. B.Sc. Semester VI		
Title of the Course and Course Code	Design and Development of Ecofriendly Products EVS3612	Number of Credits :2
Course Outcomes (COs)		
On completion of the course, the students will be able to:		
CO1	Outline the concept of Eco-design.	
CO2	Articulate the importance of various supporting schemes and organizations for startups.	
CO3	Apply skills of circular economy for evaluating sustainability	
CO4	Analyse Eco Friendly products with various tools and interpret impacts	
CO5	Review and connect the social and environmental needs with employment generation	
CO6	Design and develop eco products using natural raw material	

Unit. No.	Title of Unit and Contents	No. of Lectures
I	Eco design Concept and Principles, Factors and Guidelines for implementation, Tools used in Eco designing Ecomark scheme Eco-labelling for eco-friendly products, Eco-mark scheme, BIS implementation guidelines Circular Economy Sustainable consumption and production pattern	18

	Phases of Circular economy, Methods and sustainability in process, Case studies	
II	<p>Eco-friendly products: Need and Scope: Harmful effects of existing products in the market, Effect on environment: water, soil, plants etc., Adverse effects Human health, Benefits of eco products Marketing aspects: Market research for product, Examples: Herbal colours, soaps and dish washing liquid made from natural ingredients etc. Waste to wealth: product formulation using waste material, Paper and fabrics products Fuel pallets</p> <p>Eco Friendly product formulation Soap making: Raw material: Availability, cost, ingredients, importance Additional accessories, Safety measures, Production process: hot and cold process, Benefits and limitations</p> <p>Homemade dishwashing liquid: Raw availability, cost, preparation, benefits and limitations</p> <p>Fuel pallets: Raw material, cost, accessories, benefits and limitations</p> <p>Government schemes to support startup: Pradhan Mantri Mudra Yojana, Ministry of Micro, Small and Medium Enterprises, Govt. of India, Government funding for startup, Startup India Network, Connect with Incubators: Find incubators in your region that can support your startup's growth, Connect with Government: Reach out to the relevant Ministries or Departments</p> <p>Organizations: Governmental and nongovernmental organizations Examples: KVIC support, Zee Marathi home minister etc.</p> <p>Course conduct: Classroom teaching, videos, demonstrations, interaction with experts, workshop on entrepreneurship, training program, field survey.</p> <p>Assessment: 1) Practical skill, involvement of student, feedback and remark by interaction with NGO/ agency 2) Work in sales/ marketing of products, submission of reports etc. 3)Development of one eco-friendly product</p>	18

References:

- https://europa.eu/youreurope/business/product-requirements/compliance/ecodesign/index_en.htm#:~:text=There%20are%20certain%20products%20that,impact%20through%20the%20product's%20lifecycle.
- <https://www.dexigner.com/directory/cat/Sustainable-Design/Books>
- <https://bis.gov.in/index.php/product-certification/operation-of-eco-mark-scheme/?lang=en>

- <https://www.elsevier.com/books/the-circular-economy/sillanpaa/978-0-12-815267-6>
- <https://www.bhg.com/homekeeping/house-cleaning/cleaning-products-tools/homemade-cleaners/>
- <https://lovelygreens.com/eco-friendly-cold-process-soap-recipe-instructions/>
- <https://www.greenmatters.com/p/make-your-own-soap>
- <https://naturecode.org/biodegradable-soap/>
- <https://msme.gov.in/schemes/pm-employment-generation-program-and-other-credit-support-schemes>
- <https://www.homeminister.com/bizdetails/4959871945405174258>