

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

SYLLABUS UNDER AUTONOMY
THIRD YEAR B. Sc. Environmental Science

SEMESTER - V

Academic Year 2018-2019

**Deccan Education Society's
FERGUSON COLLEGE (AUTONOMOUS), PUNE 411004
Scheme of Course Structure (Faculty of Science)**

2018-2019

T. Y. B. Sc. - Environmental Science

Semester	Course Code	Title	Paper No.	Credits	Exam (I / E)	Marks (50 / 50)
Semester - V	EVS3501	Terrestrial and Aquatic Ecosystems Management	I	3	I / E	50 + 50
	EVS3502	Environmental Monitoring	II	3	I / E	50 + 50
	EVS3503	Remote Sensing and GIS	III	3	I / E	50 + 50
	EVS3504	Environmental Biotechnology	IV	3	I / E	50 + 50
	EVS3505	Resource Economics	V	3	I / E	50 + 50
	EVS3506	Introduction to Environmental Statistics		3	I / E	50 + 50
	EVS3507	Environmental Issues and Solutions	VI	3	I / E	50 + 50
	EVS3508	Climate Change and Sustainability		3	I / E	50 + 50
	EVS3511	Environmental Science Practical - I		2	I / E	50 + 50
	EVS3512	Environmental Science Practical - II		2	I / E	50 + 50
	EVS3513	Environmental Science Practical - III		2	I / E	50 + 50
	Semester - VI	EVS3601	Waste Treatment Technology	I	3	I / E
EVS3602		Wildlife Biology and Conservation	II	3	I / E	50 + 50
EVS3603		Environment Impact Assessment and Management	III	3	I / E	50 + 50
EVS3604		Environmental Governance and Ethics	IV	3	I / E	50 + 50
EVS3605		Environmental Toxicology, Health and Safety	V	3	I / E	50 + 50
EVS3606		Energy and Environment		3	I / E	50 + 50
EVS3607		Environmental Restoration and Remediation	VI	3	I / E	50 + 50
EVS3608		Waste Management in Smart Cities		3	I / E	50 + 50
EVS3611		Environmental Science Practical - IV		2	I / E	50 + 50
EVS3612		Environmental Science Practical - V		2	I / E	50 + 50
EVS3613		Environmental Science Project		2	I / E	50 + 50

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - I
TITLE: TERRESTRIAL AND AQUATIC ECOSYSTEMS MANAGEMENT
PAPER CODE: EVS3501

[CREDITS - 3]

Learning Objectives:

1. To encourage recognition of an "ecosystem approach" to understanding natural and anthropogenic environments.
2. To understand major pathways by which carbon, nitrogen, phosphorus and water cycle, and energy passes through, ecosystems.
3. To reconcile the apparently contradictory "taxonomic blindness" versus "taxonomic primacy" embodied within the ecosystem concept.
4. To recognize the value of various ecosystem states and conditions to human society.

	Title and Contents	No. of Lectures
Unit - I	Ecology of Terrestrial Ecosystems <ul style="list-style-type: none"> • Terrestrial Environment, terrestrial biota and biogeographic regions • General structure of terrestrial communities • Soil subsystem, vegetation subsystem • Parameters of terrestrial environment • Hotspots in India: Western Ghats and Eastern Himalaya 	08
Unit - II	Terrestrial Biodiversity and Associated Issues <ul style="list-style-type: none"> • Introduction, concept, types of Biomes • Hotspots of the world and India • Biogeographic regions of the world and India • Exploitation and Consequences of terrestrial natural resources • Sustainable management of the same, • Role of Local Government and people in conservation 	08
Unit - III	Terrestrial Ecosystem Services and Management <ul style="list-style-type: none"> • Aesthetic and cultural benefits, tourism and recreation, industry, drugs and medicines • Carbon pool and sequestration potential, etc. • Bio-geocycles, importance and applications • Bio-geocycles as a source of plant nutrients for ecosystem maintenance • Methods of terrestrial ecosystem management: remote sensing geographical information system, Joint Forest Management • Eco development program • Community based forest management, traditional methods • Impact of Tourism, Eco-tourism 	08
Unit - IV	Ecology of Aquatic Ecosystems	08

	<ul style="list-style-type: none"> • Elements of structure, functions and processes in fresh water (lakes and rivers) • Marine and estuarine ecosystems with respect to hydrology, productivity and biodiversity • Wetland soils types and redox potential • Energy flow in aquatic ecosystems • Stratification and zonation in rivers, lakes and oceans with respect to light, temperature and pressure • Major environmental (abiotic and biotic) factors and ecosystem processes. • Water quality and pollution of lakes, reservoirs, rivers and marine waters 	
Unit - V	<p>Types of Ecosystems</p> <p>Lakes and Reservoirs</p> <ul style="list-style-type: none"> • Community organization, productivity, trophic levels and food webs • Bioassessment and biocriteria 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 • Ecology of constructed wetlands. <p>Rivers</p> <ul style="list-style-type: none"> • Types of rivers, geomorphology, longitudinal profile and classification of drainage network. • Rivers and ecological continuum, riparian and flood plain wetlands. • River biodiversity, community organization, trophic structure and food webs, energy flow, negative and positive feedbacks and resilience. <p>Marine and Estuarine Ecosystems</p> <ul style="list-style-type: none"> • Structure and function of marine ecosystems; • Estuary types and genesis, organisms (plants, animals and microbes) in various ecological zones, community organization, productivity, nutrient cycling and dynamics, upwelling and down welling of nutrients • Mangroves • Coral reefs • Biodiversity in Arctic and Antarctic oceanic environment. 	08

Unit - VI	Aquatic biodiversity, Ecosystem Services <ul style="list-style-type: none"> • Landscape ecological concepts Coastal regulation zone • International conventions and protocols • Convention on Biological Diversity, Ramsar Convention and Ramsar sites in India. • Remote sensing and GIS in aquatic ecosystem management, biodiversity conservation • Climate change and aquatic ecosystem response 	08
------------------	--	----

References:

1. Groom. B. & Jenkins. M. 2000. *Global Biodiversity: Earth's Living Resources in the 21st Century*. World Conservation Press, Cambridge, UK, Gurevitch, J., Scheiner, S. M., & 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 University Press, Oxford, UK, Odum, E. P. 1971.
4. *Fundamentals of Ecology*. W. B. Saunders, Pandit, M. K., White, S. M. & Pocock, M. J. O., 2014. The Contrasting Effects of Genome Size, Chromosome Number and Ploidy Level on Plant Invasiveness: A Global Analysis.
5. *New Phytologist* 203: 697-703. Pimentel, D. (Ed.). 2011.
6. *Biological Invasions: Economic and Environmental Costs of Alien Plant, Animal and Microbe Species*. CRC Press. Singh, J. S., Singh, S. P. & Gupta, S. R. 2006.
7. *Ecology, Environment And Resource Conservation*. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. *Bioscience* 35: 700-706.

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - II
TITLE: ENVIRONMENTAL MONITORING
PAPER CODE: EVS3502

[CREDITS - 3]

Learning Objectives:

1. To aware students regarding sampling and analytical techniques in environmental monitoring.
2. To give basic knowledge about procedures of environmental monitoring
3. To correlate environmental factors and there interdependence on each other.
4. To give scientifically accurate ways of environmental interpretations with respect to environmental monitoring.

	Title and Contents	No. of Lectures
Unit - I	<p>Statistics in Environmental Monitoring</p> <ul style="list-style-type: none"> • Samples & Population <ul style="list-style-type: none"> • Concept of sample, types of sampling, Sample support, Sample size & Confidence interval • Frequency Distribution • Density Function: Mean, Mode, Median, Variance, Standard Deviation 	08
Unit - II	<p>Weather and Air Monitoring</p> <ul style="list-style-type: none"> • Weather <ul style="list-style-type: none"> • Introduction to weather system and parameters: <ul style="list-style-type: none"> • Light, Rainfall, Wind direction, Wind velocity, (Movement of pollutants), Temperature, Pressure, Humidity • Monitoring tools / instruments and their working principle • Air <ul style="list-style-type: none"> • National standards for ambient air quality • Site and parameter selection, • Monitoring of particulate matter and gases • Ambient air and work zone monitoring techniques • Monitoring tools/instruments used for the same and its work principle 	08
Unit - III	<p>Noise and Radiation Monitoring</p> <ul style="list-style-type: none"> • Noise <ul style="list-style-type: none"> • Introduction of noise & vibration; 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): 	08

	<ul style="list-style-type: none"> • Equivalent Sound Level [Leq(h)] • Radioactivity <ul style="list-style-type: none"> • Radiation types and measurement. • Detection of nuclear radiations: • G. M counter, scintillation counter, semi-conductor detector. personal dosimetry • Units of measurements • Half-life period, radiation dose measurement. 	
Unit - IV	Water and Soil Monitoring / Sampling and its Analysis <ul style="list-style-type: none"> • Water <ul style="list-style-type: none"> • Purpose / objectives of monitoring • Sampling techniques • Collection of sample, sample preservation, • Physical, chemical, biological parameters of water & its monitoring: • Standardization & calibration of monitoring instruments • General effluent standards, stream standards • Drinking water standard (IS10500 and WHO Standards) • Soil Sampling Methodology <ul style="list-style-type: none"> • Objectives of soil monitoring / testing, • Sampling and sample units, sample number, • Site selection • In-field sampling technique • Instruments / equipments used • Important soil quality indicators 	08
Unit - V	Biodiversity Monitoring <ul style="list-style-type: none"> • Vegetation Monitoring <ul style="list-style-type: none"> • Measurement of height, girth and biomass • Measurement of frequency, density and diversity • Vertebrate Monitoring <ul style="list-style-type: none"> • Transect method: Line and belt transect, point count, pug mark, pellet / dung count, call count, scat / pellet analysis and camera trapping etc. • Invertebrate Monitoring <ul style="list-style-type: none"> • Net swipe, light trap, shredder count, pit traps. 	08
Unit - VI	Instruments in Environmental Monitoring <ul style="list-style-type: none"> • pH meter • Conductivity meter • Colorimeter • Hot air oven, autoclave, laminar flow • UV Spectrophotometer, • Nitrogen (TKN) • HVS, RSPM 2.5, • Atomic absorption spectrophotometer 	08

- | | | |
|--|--|--|
| | <ul style="list-style-type: none">• Gas chromatography, Mass spectroscopy• Scanning electron microscopy | |
|--|--|--|

References:

1. Waste Water Engineering , Met Calf and Eddy, INC, Tata McGraw Hills
2. Indian Standard for Drinking Water, BSI, New Delhi. Environmental Pollution Control, C. S. Rao, Wiley Eastern Ltd.,1993
3. Air Pollution Control and Engineering, De Nevers, McGraw Hills, 1993, 10.
4. Fundamentals of Air Pollution, Samuel, J. W., 1971, Addison Wesley Publishing
5. Fundamentals of Environmental Pollution, Krishnan Khannan, S. Chand and Company Ltd., 1994.
6. Noise Pollution, Vandana Pandey, Meerut Publishers, 1995.
7. Environmental Pollution Control, C. S. Rao, Wiley Eastern Ltd., 1993.
8. Air Pollution Control and Engineering, De Nevers, McGraw Hills, 1993.
9. Fundamentals of Environmental Pollution, Krishnan Khannan, S. Chand and Company Ltd., 1994.
10. Environmental Chemistry, A. K. De., New Age Intl. Pub Co, New Delhi, 1990.
11. Environmental Pollution Analysis - S. M. Khopkar.

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - III
TITLE: REMOTE SENSING AND GIS
PAPER CODE: EVS3503

[CREDITS - 3]

Learning Objectives:

1. To provide students basic level competency with geospatial analysis.
2. To learn efficient use GPS and Google Earth / Bhuvan Earth.
3. To understand Geo referencing and subsetting, ground-truthing surveys and visual image analysis.

	Title and Contents	No. of Lectures
Unit - I	<p>Fundamentals, Principles and Process of Remote Sensing</p> <ul style="list-style-type: none"> • Electromagnetic Radiations (EMR) • Electromagnetic Spectrum • Interaction between Matter and EMR • Types of Remote Sensing • Principles and Process of Remote Sensing • Types of Remote Sensing Systems: <ul style="list-style-type: none"> • Visual Remote Sensing • Optical Remote Sensing • Infrared Remote Sensing • Microwave Remote Sensing • Radar Remote Sensing • Satellite Remote Sensing • Airborne Remote Sensing • Acoustic and near-acoustic remote sensing 	08
Unit - II	<p>Image Analysis</p> <ul style="list-style-type: none"> • Visual Interpretation • Digital Processing: <ul style="list-style-type: none"> • Preprocessing • Enhancement • Transformation • Classification • Integration 	08
Unit - III	<p>Applications of Remote Sensing</p> <p>Applications in the field of:</p> <ul style="list-style-type: none"> • Agriculture • Forestry • Geology Hydrology • Sea Ice • Land cover • Mapping • Oceans and Coastal 	08
Unit - IV	Introduction to GIS	08

	<ul style="list-style-type: none"> • Definition • Components • Functions and advantages of GIS • Process of GIS • Spatial data model and attribute data 	
Unit - V	Geospatial Analysis <ul style="list-style-type: none"> • Introduction • Geospatial data analysis methods • Database query • Geospatial measurements • Overlay Operations • Network Analysis • Surface Analysis • Geo-visualization 	08
Unit - VI	Modern Trends of GIS <ul style="list-style-type: none"> • Integration of GIS and Remote Sensing • Integration of GIS and Multimedia • Mobile GIS • Collaborative GIS (CGIS) 	08

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 Press.
2. Lillisand, 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 (2000): 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. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - IV
TITLE: ENVIRONMENTAL BIOTECHNOLOGY
PAPER CODE: EVS3504

[CREDITS - 3]

Learning Objectives:

1. To introduce students about various concepts and terminologies applied in environmental biotechnology.
2. To develop problem solving approach among student by applying knowledge of environmental biotechnology.
3. To learn techniques applicable in the field of agriculture, fuel production, resource recovery and waste management.
4. To create awareness about benefits and limitations of biotechnology.

	Title and Contents	No. of Lectures
Unit - I	Environmental Biotechnology <ul style="list-style-type: none"> • Meaning, objectives, need and scope • Applications of environmental biotechnology 	04
Unit - II	Biotechnology for Sustainable Agriculture <ul style="list-style-type: none"> • Biopesticides: Classification of biopesticides: <ul style="list-style-type: none"> • Microbial biopesticides production process, stabilization, formulation, mode of action • Plant Product as biopesticides e.g. neem pesticides. • Biofertilizers: Types, production and role in soil fertility, agro based solid waste & its use. • Composting: Composting technology, design aspect, composting process, temperature trends and influencing factors • Vermicomposting: Earthworm life cycle, chemical characteristic of vermicompost, operating process. 	12
Unit - III	Bioremediation <ul style="list-style-type: none"> • Microbial Remediation Process <ul style="list-style-type: none"> • Principles of bioremediation • Concept of bioaugmentation and biostimulation. • Factors affecting bioremediation process: microbial metabolism, environmental conditions and nature of pollutant. • Types of Bioremediation <ul style="list-style-type: none"> • Phytoremediation: Concept, factors affecting phytoremediation, plants useful for phytoremediation, removal of metals and organic pollutants. • Types of phytoremediation: phytoextraction, phytostabilization, Rizofiltration, Phytotransformation, phytovolatilization. • Current developments in the process. 	10

Unit - IV	Natural Resource Recovery <ul style="list-style-type: none"> • Oil recovery <ul style="list-style-type: none"> • Microbially Enhanced Oil Recovery (MEOR) • Methods used and role of microorganism in MEOR • Metal recovery <ul style="list-style-type: none"> • Types of bioleaching • Methods for bioleaching, metal precipitation, microorganisms used • Advantages and disadvantages of bioleaching 	08
Unit - V	Genetically Modified Organisms (GMOs): Environmental Issues and Biosafety <ul style="list-style-type: none"> • GMO's concept • Environmental ethical social and health problems associated with GMO's • Bioethics for GMO's • Biosafety regulations, Cartagena protocol 	06
Unit - VI	Biopolymers, Biosensors and Bioindicators <ul style="list-style-type: none"> • Biopolymers and bioplastics What are biopolymers? Types of biopolymers and its applications. • Biosensors: What is a biosensor? Applications of biosensors in environmental monitoring. • Bioindicators Concept of bioindicators, Plankton community as indicators of water pollution; microbiological quality of potable waters, indicator organisms, coliforms and E.coli, fecal streptococci, clostridia, heterotrophic plate counts etc. lichens as air pollution indicators. 	08
References: <ol style="list-style-type: none"> 1. Environmental Biotechnology. M. H. Fulekar. 2. Environmental Biotechnology: Basic Concepts and Applications. Indu Shekhar Thakur, I. K. International Pvt. Ltd. 3. Environmental Biotechnology. Alan Scragg, Oxford University Press. 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - V
TITLE: RESOURCE ECONOMICS
PAPER CODE: EVS3505

[CREDITS - 3]

Learning Objectives:

1. To introduce students to the fundamentals of environmental economics.
2. To understand basic concepts of economics to familiarize students with absence of market, demand and supply in nature.
3. To introduce modern concepts of environmental economics.
4. To learn importance in conservation of biodiversity and ecosystems through understanding of economic costs associated with these.

	Title and Contents	No. of Lectures
Unit - I	Introduction to Economics <ul style="list-style-type: none"> • Definition and scope of Environmental Economics • Environmental economics as a branch of Environmental Science • Principles of Environmental Economics • Need of Environmental economics to understand economic benefits of conservation • Refuse to use, Reuse, Reduce, Recover and Recycle. 	08
Unit - II	Environmental Economics <ul style="list-style-type: none"> • Main characteristics of environmental goods; • Marginal analysis; markets and market failure; social benefit, costs and welfare functions; • Meaning and types of environmental values; • Measures of economic values; tangible and intangible benefits; • Social cost benefit analysis; cost-effectiveness analysis. 	08
Unit - III	Economic Solutions to Environmental Problems <ul style="list-style-type: none"> • Social costs and benefits of environmental programmes • Marginal social benefit of abatement, • Marginal social cost of abatement; • Pollution Control: Policies for controlling air and water pollution, • Disposal of toxic and hazardous waste - standards vs. emissions charges, • Environmental subsidies • Modelling and emission charges; • Polluter pay principles 	08
Unit - IV	Natural Resource Economics <ul style="list-style-type: none"> • Disadvantages of non renewable fuel • Issues of utilisation of water • Differential cost of drinking water 	08

	<ul style="list-style-type: none"> • Impacts of water pollution • Command & continual regime • Regulation Vs initiative • Economic instruments for promoting environmental conservation. 	
Unit - V	Economic Instruments <ul style="list-style-type: none"> • Growth and environment, • Environmental audit and accounting, • Kuznets curve, environmental risk analysis, • Assessing benefits and cost for environmental decision making, • Green labelling, green supply chain • Principles of cost-benefit analysis, 	08
Unit - VI	Valuation of Natural Resources <ul style="list-style-type: none"> • Approaches of valuation: Stated preference and Reveal preference • Techniques of valuation: Travel cost method, benefit transfer method, Hedonic pricing, Contingent valuation, Choice modeling. 	08

References:

1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B. O. Levin, S., Maler, K. G., Perrings, C., Pimentel, D. 1995. Economic Growth, Carrying Capacity and the Environment. *Ecological Economics* 15: 91-95.
2. Hanley, N., Shogren, J. F., & White, B. 2007. *Environmental Economics: In Theory and Practice*. Palgrave Macmillan.
3. Kolstad, C. D. 2010. *Environmental Economics*. Oxford University Press.
4. Perman, R. 2003. *Natural Resource and Environmental Economics*. Pearson Education.
5. Singh, K. & Shishodia, A. 2007. *Environmental Economics: Theory and Applications*. Sage Publications.
6. Thomas, J. M. & Callan, S.J. 2007. *Environmental Economics*. Thomson Learning Inc.
7. Tietenberg, T. 2004. *Environmental and Natural Resource Economics* (6th edition). Pearson Education Pvt. Ltd.
8. Tietenberg, T. H. & Lewis, L. 2010. *Environmental Economics and Policy*. Addison - Wesley.
9. Turner, R. K., Pearce, D., & Bateman, I. 1994. *Environmental Economics: An Elementary Introduction*. Harvester Wheatsheaf.

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - VI
TITLE: INTRODUCTION TO ENVIRONMENTAL STATISTICS
PAPER CODE: EVS3506

[CREDITS - 3]

Learning Objectives:

1. To introduce a systematic technique of statistical theory
2. To learn methods for handling environmental data.
3. To learn applications of statistics in understanding and quantifying change in environmental science.

	Title and Contents	No. of Lectures
Unit - I	Introduction <ul style="list-style-type: none"> • Role of statistics in environmental research • Introduction to concept of statistics, population, sample, data • Concept of univariate, bivariate data • Data sampling • Types of sampling: Random and non-random 	08
Unit - II	Data Presentation <ul style="list-style-type: none"> • Types of data: Discrete and continuous data, frequency and non-frequency data • Frequency distributions • Sample collection and data presentation methods • Diagrammatic methods • Graphical methods 	08
Unit - III	Measures of Central Tendency <ul style="list-style-type: none"> • Arithmetic mean • Median • Mode • Geometric mean • Harmonic mean 	08
Unit - IV	Measures of Dispersion <ul style="list-style-type: none"> • Range • Mean deviation • Variance • Standard deviation • Skewness and kurtosis 	08
Unit - V	Probability Assessment <ul style="list-style-type: none"> • Standard discrete and continuous distributions • Random experiment: Trial, sample point, definitions of equally likely, mutually exclusive and exhaustive events, definition of probability, classical and relative frequency approach to probability • Discrete random variables: Bernoulli random variable, 	08

	Binomial random variable, Poisson random variable. <ul style="list-style-type: none"> • Continuous random variables • Normal probability distributions 	
Unit - VI	Applications <ul style="list-style-type: none"> • Introduction to indices used for various environmental studies • Examples based on ecology and ecosystem, weather and air monitoring, soil quality data, water and effluent data and any other pollution studies 	08
References: <ol style="list-style-type: none"> 1. Introduction to Ecological Sampling by Bryan F. J. Manly. 2. Statistics for Environment, Vic Barnett, K. Feridun Turkman, Commission of the European Communities, Wiley Publications. 3. Biostatistics by Khan and Khanum. 4. Biostatistical Analysis by Zar, Jerrold H., Prentice Hall, (India). 5. Statistics for Environmental Science and Management by Manly Bryan F. J. 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - I
TITLE: ENVIRONMENTAL ISSUES AND SOLUTIONS
PAPER CODE: EVS3507

[CREDITS - 3

Learning Objectives:

1. To understand important environmental issues at global, national and local level.
2. To identify environmental problems faced by different countries of the world.
3. To find unique approaches towards solution of these issues.
4. To develop critical understanding of international and national efforts.
5. To understand and correlate ideal practices solution of the environmental issues.
6. To identify new areas of research problems.

	Title and Contents	No. of Lectures
Unit - I	Global Environmental Issues - Part I <ul style="list-style-type: none"> • Ozone Depletion • Acid Rain • Desertification • Global Warming and Climate Change • Energy Crisis • Genetically Modified Organisms • WTO and Environmental Issues • Species Loss 	08
Unit - II	Global Environmental Issues - Part II <ul style="list-style-type: none"> • E-Waste Management • Food Crisis • Biological Warfare • Eco-Terrorism • Issues Related to Shipping • Water Crisis • Population Explosion • Wastelands 	08
Unit - III	International Efforts <ul style="list-style-type: none"> • Sustainable Development and Solutions • Clean Development Mechanism • Carbon Emissions • Carbon Credits • Carbon Sequestration • Important International Agreements • Green Politics • Role of IUCN and UNEP 	08
Unit - IV	Environmental Issues in India <ul style="list-style-type: none"> • Soil Erosion 	08

	<ul style="list-style-type: none"> • Alkaline and Saline Soil • Industrial and Vehicular Air Pollution of Cities • Water Quality Degradation • Municipal Solid Wastes • Issues with Slums • Droughts and Floods • Eutrophication • Dams and Displacement 	
Unit - V	National Efforts <ul style="list-style-type: none"> • Citizen Participation in Environmental Issues • The National Environmental Advisory Forum • Right To Environmental Information • Laws and Policies on Environmental Protection • Ganga Action Plan and Interlinking of Rivers • Disaster Management Plan • Wasteland Development Programme • Fly Ash Utilization Policy • Rainwater Harvesting Policy 	08
Unit - VI	Environmental Movements and Case Studies <ul style="list-style-type: none"> • Genesis of Environmental Movements • Narmada Bachao Andolan • Chipko Movement • Save Silent Valley Movement • Tehri Dam Conflict • Environmental Movements in Developed Countries • Indian Case Studies to Solve Issues 	08
References:		
<ol style="list-style-type: none"> 1. Santra S. C.: Environmental Science by New Central Book Agency (P) Limited, 2001. 2. Sharma B. K.: Environmental Chemistry. Goel Publishing House, Meerut, 1997. 3. De A. K.: Environmental Chemistry, New Age International (P) Limited, 2017. 4. Rangarajan: Environmental Issues in India: A Reader, Pearson Education India, 2006. 5. Singh N. and Thakur A. K.: Climate Change and Environmental Issues, The Energy Resources Institute (TERI) 2016. 6. Frances Harris: Global Environmental Issues, Wiley-Blackwell, 2012. 7. Pickering K.: An Introduction to Global Environmental Issues, Routledge, 1994. 8. Daniel D. Chiras: Environmental Science, Jones and Bartlett Publishers, 2001. 9. Various Case Studies from Research Articles. 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PAPER - VIII
TITLE: CLIMATE CHANGE AND SUSTAINABILITY
PAPER CODE: EVS3508

[CREDITS - 3]

Learning Objectives:

1. To introduce students the basic understanding of anthropogenic intervention in global climate change.
2. To explore effects of global changes on human communities.
3. To learn initiatives taken at global and regional levels to combat global climate change.

	Title and Contents	No. of Lectures
Unit - I	Global Warming <ul style="list-style-type: none"> • Earth's climate, state of equilibrium since ages • Trend of global warming and climate change • Drivers of global warming and the potential of different GHG causing climate change • CO₂ as a vulnerable component of atmosphere • Global impacts • Suffering of poor section of society 	08
Unit - II	Impacts of Global Warming <ul style="list-style-type: none"> • Concept of Atmospheric windows • Impact of climate change on atmosphere • Change in weather patterns, sea level rise, agricultural productivity • Detection of impact of global warming & climate change. • Introduction to carbon dating, ice core study, tree ring data analysis, etc. 	08
Unit - III	Ozone Layer Depletion <ul style="list-style-type: none"> • Ozone layer and its importance • Causes of ozone layer depletion • Chapman cycle • Ozone depleting substances (ODS) • Effects of ozone layer depletion 	08
Unit - IV	Climate Change and Policy <ul style="list-style-type: none"> • International agreements • Montreal protocol 1987 • Kyoto protocol 1997, Responsibilities of annexure A & B countries • Convention on climate change • Carbon credit and carbon trading • Clean development mechanism 	08
Unit - V	Sustainable Management - I <ul style="list-style-type: none"> • Current international treaties COP • Regulatory standards 	08

	<ul style="list-style-type: none"> • India's role in abating climate change • Challenges and current issues 	
Unit - VI	Sustainable Management - II <ul style="list-style-type: none"> • Sustainable management in practices and advantages of sustainability • CSR and sustainability • Examples to explore a range of different theoretical and practical approaches to understanding and influencing pro-sustainable behaviour. • Sustainable management for producers and consumers 	08

References:

1. Barry, R. G. 2003. *Atmosphere, Weather and Climate*. Routledge Press, UK.
2. Gillespie, A. 2006. *Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations*. Martinus Nijhoff Publishers.
3. Hardy, J. T. 2003. *Climate Change: Causes, Effects and Solutions*. John Wiley & Sons.
4. Harvey, D. 2000. *Climate and Global Climate Change*. Prentice Hall.
5. Manahan, S. E. 2010. *Environmental Chemistry*. CRC Press, Taylor and Francis Group.
6. Maslin, M. 2014. *Climate Change: A Very Short Introduction*. Oxford Publications.
7. Mathez, E. A. 2009. *Climate Change: The Science of Global Warming and Our Energy Future*. Columbia University Press.
8. Mitra, A. P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. *Climate Change and India*. Universities Press, India.
9. Philander, S. G. 2012. *Encyclopedia of Global Warming and Climate Change* (2nd edition). Sage Publications.

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PRACTICAL - I
PAPER CODE: EVS3511

[CREDITS - 2]

Practicals Based on EVS3501: Terrestrial and Aquatic Ecosystems Management

- | | |
|-----|--|
| 1. | Study of soil microflora from root nodules |
| 2. | Study of keystone species from a forest region |
| 3. | Assessment of values of a wetland |
| 4. | Comparative analysis of oligotrophic and eutrophic water bodies. |
| 5. | Quantitative analysis of phytoplankton and determination of percentage composition by Lackey's drop count method |
| 6. | Study of wetland ecosystem (field practical) |
| 7. | Study of swamp (mangrove) ecosystem of Konkan coast (Visit), Studies on benthic fauna |
| 8. | Study of threat assessment model for an ecosystem |
| 9. | Estimation of chlorophyll content from given plant material |
| 10. | Estimation of Free CO ₂ from given sample |

Practicals Based on EVS3502: Environmental Monitoring

- | | |
|-----|---|
| 1. | Study of weather maps, interpretation for wind direction, rainfall |
| 2. | Air sampling and analysis for PM (SPM, RSPM) |
| 3. | Air sampling and analysis for SO _x |
| 4. | Air sampling and analysis for NO _x |
| 5. | Noise measurement degree of annoyance from selected areas |
| 6. | Estimation of sodium adsorption ratio from given water sample |
| 7. | Estimation of chromium content from given wastewater sample |
| 8. | Determination of cation exchange capacity (CEC) of soil. |
| 9. | Estimation and calculation frequency, abundance and density by line / belt transect |
| 10. | Preparation of acid digests for heavy metal analysis |
| 11. | Determination of minimum area of sampling for vegetation study |
| 12. | Estimation of water quality index |
| 13. | Estimation of air pollution index |
| 14. | Estimation of sludge volume index |
| 15. | Estimation of dissolved oxygen from given water sample |

T.Y. B.SC. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PRACTICAL - II
PAPER CODE: EVS3512

[CREDITS - 2]

Practicals Based on EVS3503: Remote Sensing and GIS

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: Environmental Biotechnology

1.	Use of microorganisms as bio-indicators 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 - Indore method & Bangalore method.
4.	Vermicomposting of farm / other solid wastes.
5.	Qualitative and quantitative estimation of compost and vermicompost.
6.	Study of phytoremediation techniques for removal of pollutants.
7.	Isolation of mineral leaching bacteria.
8.	Calculating footprint of GMOs.
9.	Use of biologically derived nanoparticles for water treatment.
10.	Visit to biotechnology laboratory / research center.
11.	Biosorption studies by using microbes and waste material through column

T.Y. B.SC. (ENVIRONMENTAL SCIENCE) SEMESTER - V
ENVIRONMENTAL SCIENCE PRACTICAL - III
PAPER CODE: EVS3513

[CREDITS - 2]

Practicals Based on EVS3505: Resource Economics

1.	Study on methods used in economic valuation of natural resources
2.	Calculations based on economic valuation
3.	Study of economic instruments used for analysis
4.	Questionnaire approach for cost benefit analysis
5.	Environmental audit for any two natural resources
6.	Estimation of parameters for preference analysis
7.	Economic evaluation of selected product
8.	Estimation of net present value of any project

Practicals Based on EVS3506: Introduction to Environmental Statistics

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.	Calculations based on probability assessment.
8.	Introduction to software used for basic statistical analysis

Practicals Based on EVS3507: Environmental Issues and Solutions

1.	Analysis of fly ahs for various parameters
2.	Analysis of solid waste leachate for selected wastewater parameters
3.	Questionnaire survey based genetically modified organisms
4.	Study of acid rain solution and its impact on physical materials
5.	Effect of acid rain solution on plants/seed germination study
6.	Study of ecofriendly products available in market
7.	Understanding relation between drought and groundwater quality
8.	Estimation of oil and grease from given water sample
9.	Estimation of organic carbon from given plant sample
10.	Use of online software for trajectory analysis
11.	Study of carbon sequestration in laboratory by addition of artificial agents
12.	Participation in at least one activity run by international NGO to solve environmental issues
13.	Study on issues associated with dams
14.	Study on issues of vehicular pollution on city on physical and biological areas
15.	Understanding degradation of river ecosystem
16.	Estimation of rainwater harvesting potential of Fergusson College campus

Practicals Based on EVS3508: Climate Change and Sustainability

1.	Study on climate change modelling
2.	Study on carbon foot print mapping
3.	Assessment of global warming potential of greenhouse gases

4.	Case studies based on sustainable management
5.	Current climate change conventions at international and national level
6.	Innovative practices for sustainable management in organization
7.	Estimation of carbon sequestration potential of selected area/ plant
8.	Estimation of atmospheric ozone by using

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

SYLLABUS UNDER AUTONOMY
THIRD YEAR B. Sc. Environmental Science

SEMESTER - VI

Academic Year 2018-2019

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - I
TITLE: WASTE TREATMENT TECHNOLOGY
PAPER CODE: EVS3601

[CREDITS - 3]

Learning Objectives:

1. To make students aware with various types of waste and there treatment options.
2. To learn basics of each type of waste treatment technology.
3. To understand various ways to recover useable materials from waste.
4. To learn waste and there possible treatments with presently available technologies.

	Title and Contents	No. of Lectures
Unit - I	Solid, Biomedical and Hazardous Waste: <ul style="list-style-type: none"> • Sources and generation of waste • Characterization of waste • Concept of resource recovery from waste • Refuse derived fuel (RDF), • Different WTE processes: Combustion, pyrolysis, landfill gas (LFG) recovery, anaerobic digestion, gasification 	08
Unit - II	Air Treatment: <ul style="list-style-type: none"> • Prevention and control of air pollution through different technologies • 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 	08
Unit - III	Noise Control: <ul style="list-style-type: none"> • 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 	08
Unit - IV	Water: <ul style="list-style-type: none"> • Flow chart for waste water treatment. • Selection of appropriate unit operations for the treatment: <ul style="list-style-type: none"> • Primary treatment • Secondary treatment (Biological): Aerobic and anaerobic methods. • Tertiary treatment. • Advance wastewater treatment processes. 	08

Unit - V	<p>Land / Soil Treatment:</p> <ul style="list-style-type: none"> • Controlling land degradation • Soil Erosion - Causes - Water & Wind Erosion of Soil. • Control of Erosion & Soil Conservation Methods <p>Biological Methods:</p> <ul style="list-style-type: none"> • To reduce dependency on chemicals - Use of sustainable land use planning, biofertilizers & biopesticides, conservational tillage, mixed cropping, crop rotation, biological pest management., organic farming • Bio / Phytoremediation of contaminated sites. <p>Chemical Methods:</p> <ul style="list-style-type: none"> • Ex-situ - acid leaching. • In-situ - pH correction using lime or gypsum. <p>Physical / Mechanical Methods:</p> <ul style="list-style-type: none"> • Contour trenches, continuous contour benches, live hedges. • Ex-situ-Heavy metal immobilization through vitrification. • In-situ - appropriate cultivation practices, soil vapour extraction. 	08
Unit - VI	<p>Nuclear and Radioactive Waste:</p> <ul style="list-style-type: none"> • Control of Nuclear Pollution. • Control of release & exposure. • Proper treatment & disposal of nuclear waste. • Protection to workers. • 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. • Three Miles and Chernobyl accidents. 	08
<p>References:</p> <ol style="list-style-type: none"> 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. Egbal. 7. Waste Water Engineering, Met Calf & 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. Eisendbud, Academic Press 11. Essentials of Nuclear Chemistry - II, T. Arnikar, Wiley Easter. 12. Nuclear Chemistry Through Problems - II, T. Arnikar & N. S. Rajurkar, New Age Int. (P) Ltd. 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - II
TITLE: WILDLIFE BIOLOGY AND CONSERVATION
PAPER CODE: EVS3602

[CREDITS - 3]

Learning Objectives:

1. To learn basics of wildlife biology and major groups of plants and animal with their habitats.
2. To know the threats to wildlife and nature and critically assess relationships between human and scientific perspectives on conservation.
3. To provide insights on methods of assessing wildlife.
4. To provide a window to ongoing efforts for conservation at national and international levels.

	Title and Contents	No. of Lectures
Unit - I	Basics of Wildlife Biology <ul style="list-style-type: none"> • Introduction • Concept of Wildlife Biology • Definition of Wildlife (Refer to Wildlife Protection Act) • Examples of protected wildlife species 	08
Unit - II	Wildlife Classification and Habitats <ul style="list-style-type: none"> • Diversity of major groups of plants and animals: Plants <ul style="list-style-type: none"> • Algae, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms (Monocots and Dicots) Animals <ul style="list-style-type: none"> • Invertebrates - Arthropods (Insects, Arachnids, Crustaceans, Millipedes, Centipedes). Vertebrates- Mammals, Birds, Fish, Reptiles, Amphibians, Habitats of Wildlife: Aquatic and Terrestrial 	08
Unit - III	Threats to Wildlife <ul style="list-style-type: none"> • Habitat destruction • Developmental projects • Urbanization • Agricultural expansions • Excessive harvesting and Poaching • Human-wildlife conflict • Examples of excessive exploitation of plants and animals. 	08
Unit - IV	Concept of Conservation <ul style="list-style-type: none"> • Concept of Nature Conservation • CBD, PAN • Conservation approaches: Species, habitat, ecosystem • Objectives and challenges of nature conservation • In-situ and Ex-situ conservation 	08

	<ul style="list-style-type: none"> • Traditional method of conservation 	
Unit - V	Wildlife Assessment <ul style="list-style-type: none"> • Population assessment techniques for flying insects • Birds and Mammals: Transects, point counts, net swipes • 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 	08
Unit - VI	Efforts for Conservation <ul style="list-style-type: none"> • 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 	08

References:

1. Larry W. Canter, Environment Impact Assessment, McGraw-Hill Book Company, New York.
2. G. J. Rau and C. D. Weeten, Environmental Impact Analysis Hand Book, McGraw-Hill, 1980.
3. Vijay Kulkarni and T. V. Ramchandra. Environmental Management, Capital Publishing Co.
4. Mhaskar A. K., Environmental Audit, Enviro Media Publications.
5. S. K. Dhameja, Environmental Engineering and Management, S. K. Kalaria and Sons Publishers.
6. William Blackman, Basic Hazardous Waste Management, Taylor & Francis, 1995.
7. Vanguilder, Cliff, Hazardous Waste Management: An Introduction. Mercury Learning and Information, 2011.
8. M. S. Bhatt, Asheref Illiyan, Solid Waste Management: An Indian Perspective, Synergy Books India, 2012.
9. William Blackman, Basic Hazardous Waste Management, Taylor & Francis, 1995.
10. Singh Anantpreet and Kaur Sukhjit, Biomedical Waste Disposal, Jaypee Brothers.
11. Ronald E. Hester and Roy M. Harrison, Electronic Waste Management, RSC Publishing.

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - III
TITLE: ENVIRONMENT IMPACT ASSESSMENT AND MANAGEMENT
PAPER CODE: EVS3603

[CREDITS - 3]

Learning Objectives:

1. To learn need and importance of impact analysis.
2. To learn basic concepts of Environmental impact assessment.
3. To recognize the growing need of industry to anticipate and incorporate environmental concerns and risk while developing large scale projects.
4. To evaluate the contemporary tools and techniques to assess various environmental management systems.

	Title and Contents	No. of Lectures
Unit - I	Introduction to EIA <ul style="list-style-type: none"> • Definition, introduction and concept • Historical development of EIA • Scope and methodologies • Role of project proponents, project developer and consultants • Term of reference 	08
Unit - II	EIA Process <ul style="list-style-type: none"> • EIA Process • Impact identification and prediction • Baseline data collection • EIS and EMP 	08
Unit - III	Types <ul style="list-style-type: none"> • Rapid EIA • Strategic Environmental Assessment • Social Impact Assessment • Cost-benefit analysis 	08
Unit - IV	Regulations and Case studies <ul style="list-style-type: none"> • EIA regulations in India • Status of EIA in India • Current issues • Case studies based on hydropower / thermal projects. 	08
Unit - V	EMS - Part I <ul style="list-style-type: none"> • Introduction to Environment management systems • Environment management in organization • Environmental and economic sustainability • Concept of EMAS and EMS standards and tools • Introduction to ISO 14000 Family • Role and scope of Technical committee • PDCA cycle 	08
Unit - VI	EMS - Part II	08

	<ul style="list-style-type: none"> • Guidelines of ISO 14001: 2015 standards for implementation • Environmental Audit: Concept, process and types 	
<p>References:</p> <ol style="list-style-type: none"> 1. Barrow, C. J. 2000. <i>Social Impact Assessment: An Introduction</i>. Oxford University Press. 2. Glasson, J., Therivel, R., Chadwick, A. 1994. <i>Introduction to Environmental Impact Assessment</i>. London, Research Press, UK. 3. Judith, P. 1999. <i>Handbook of Environmental Impact Assessment</i>. Blackwell Science. 4. Marriott, B. 1997. <i>Environmental Impact Assessment: A Practical Guide</i>. McGraw-Hill, New York, USA 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - IV
TITLE: ENVIRONMENTAL GOVERNANCE AND ETHICS
PAPER CODE: EVS3604

[CREDITS - 3]

Learning Objectives:

1. To understand important provisions of environmental laws in India and international agreements.
2. To understand role of constitution and various administrative mechanisms created under these laws.
3. To identify wide nature, need and importance of environmental governance.
4. To understand the concept of environmental ethics and challenges associated with it.
5. To explore issues related to urban governance and legislation.

	Title and Contents	No. of Lectures
Unit - I	Constitutional Provisions and National Policies <ul style="list-style-type: none"> • Constitutional Provisions for Protection • Article 48 (A) and 51 (A) G • National Environmental Policy • National Forest Policy • Ecomark Scheme • National Conservation Strategy and Policy Statement • Environment Pollution Control Authority • Public Interest Litigation 	08
Unit - II	Antipollution Acts <ul style="list-style-type: none"> • Air Act • Water Act • Environment Protection Act • Motor Vehicle Act • Public Liability Insurance Act • National Environmental Tribunal Act 	06
Unit - III	Antipollution Rules <ul style="list-style-type: none"> • Noise Pollution Rules • E-Waste Management Rules • Plastic Waste Management Rules • Hazardous Waste Management Rules • Biomedical Waste Management Rules • Municipal Waste Management Rules 	06
Unit - IV	Environmental Conservation Acts <ul style="list-style-type: none"> • Wildlife Act • Biological Diversity Act • Forest Conservation Act • Prevention of Cruelty to Animals Act • Protection of Plant Varieties and Farmers' Rights Act 	08

	<ul style="list-style-type: none"> • Regulation of Genetically Modified Organisms in India 	
Unit - V	Earth Summits and Conventions <ul style="list-style-type: none"> • International Environmental Law • Declaration of the United Nations Conference on the Human Environment • Rio Declaration on Environment and Development • Convention on Biological Diversity • United Nations Framework Convention on Climate Change • Paris Climate Change Agreement 	06
Unit - VI	International Environmental Conventions <ul style="list-style-type: none"> • Vienna Convention • Basel Convention • Ramsar Convention • International Convention for the Prevention of Pollution from Ships • Convention on Long-Range Transboundary Air Pollution • Stockholm Convention on Persistent Organic Pollutants 	06
Unit - VII	Environmental Ethics and India <ul style="list-style-type: none"> • Earth Ethics and Business Ethics • Ethical Theories Applied to Environment • Ethical Issues in India • Role of Indian Culture in Development of Ethics 	04
Unit - VIII	World Environmental Ethics <ul style="list-style-type: none"> • Role of Western Philosophers in Development of Ethics • Religions and Environmental Ethics • Value Education and Ethics • Challenges of World Environmental Ethics 	04

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. Des Jardins, 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. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - V
TITLE: ENVIRONMENTAL TOXICOLOGY, HEALTH AND SAFETY
PAPER CODE: EVS3605

[CREDITS - 3]

Learning Objectives:

1. To introduce students about various concepts of toxicology.
2. To familiar students about sources and toxic effects of various environmental contaminants.
3. To learn methods used for monitoring of toxicity.
4. To aware students about occupational health hazards and safety measures, laws and regulations for handling / disposal of toxic materials.

	Title and Contents	No. of Lectures
Unit - I	<p>Introduction to Environmental Toxicology</p> <ul style="list-style-type: none"> • Concept of environmental toxicology, toxicants and xenobiotics • Parameters of toxicity testing: Effective Doses (EDs), No Observed Adverse Effect Level (NOEL), LC₅₀ LD₅₀ etc. • Factors determining adverse effects: Intrinsic toxicity, dose, exposure conditions, response of host • Toxic effects: <ul style="list-style-type: none"> • Cellular, biochemical or macromolecular changes • Systemic toxic effects: acute toxicity, subchronic toxicity, chronic toxicity • Mixed exposures effects: Additive effects • Synergistic effects, antagonistic effects • Mutagenic, teratogenic, carcinogenic effects • Toxicity test: Range finding, screening, definitive toxicity test. 	08
Unit - II	<p>Industrial and Environmental Toxicants</p> <ul style="list-style-type: none"> • Classification of toxic materials. • Industrial toxicants and hazardous materials • Physiological and metabolic effects of toxicants <ul style="list-style-type: none"> • Toxicity of VOC and organic solvents used in industry • Metal Toxicity: Hg, Pb, As, Cd etc. • Non metal toxicity: Nitrate-Nitrite poisoning, salt poisoning, Fluorosis, urea poisoning, acid and alkali poisoning. • Phytotoxicity, zootoxicity, microbial toxicity • Radiation hazards: Biological effects. • Biomagnification and Biotransformation of toxicants 	08
Unit - III	<p>Water and Airborne Diseases</p> <ul style="list-style-type: none"> • Concept of epidemiology, potential and widespread effects of water and airborne diseases. • Endemic, epidemic and pandemic diseases. 	08

	<ul style="list-style-type: none"> • Waterborne bacterial and viral diseases: Causative agents, spread of disease symptoms preventive and curative measures, case studies. • Airborne bacterial and viral diseases: Causative agents, spread of disease symptoms preventive and curative measures, case studies. • Bioterrorism and protective measures. 	
Unit - IV	Protection, Prevention and Control of Diseases <ul style="list-style-type: none"> • Potential threats to human health and well-being. • Direct and indirect effects of stressful environment on human health. • Problems associate with assessment of impact of toxic exposure. • Hierarchy of disease and hazard control at work place environment and personal level. • Disease control through biological and biochemical methods. 	08
Unit - V	Occupational Health and Safety <ul style="list-style-type: none"> • Concept of hazard, risk and safety. • Occupational health hazards in industries, case studies. • Introduction to ISO18001: Guidelines for implementations. 	08
Unit - VI	Toxicology and Law <ul style="list-style-type: none"> • Regulatory development • Regulatory agencies • Toxic substances control act • Occupational safety and health act • Hazardous waste rule • National Institute for health and safety 	08
References: <ol style="list-style-type: none"> 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. 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - VI
TITLE: ENERGY AND ENVIRONMENT
PAPER CODE: EVS3606

[CREDITS - 3]

Learning Objectives:

1. To sensitize students about current problems of energy resource utilization and crisis.
2. To provide students with a broad understanding of the existing energy resources, issues related to energy and the environment.
3. To provide fundamental and technical knowledge about methods used for energy generation from various sources.
4. To develop problem solving approach among students with reference to energy resources
5. To develop think approach among students challenges and possible paths to sustainable energy generation and use.

	Title and Contents	No. of Lectures
Unit - I	<p>Introduction</p> <ul style="list-style-type: none"> • Global energy resources and their classification • Energy forms and transformation • Past, present, and future technologies for capturing and integrating these resources into our energy infrastructure • Generation and utilization in rural and urban environments • Energy demand and use in domestic • Industrial, agriculture and transportation sector 	08
Unit - II	<p>Solar and Wind Energy</p> <ul style="list-style-type: none"> • Solar storage system: Solar pond, solar water heating, solar cooker, solar electric power generation - solar photovoltaic. • Wind: Basic principles of wind energy conversion <ul style="list-style-type: none"> • Site selection • Classification of wind energy generation system: Horizontal axis and vertical axis • Mechanism of wind energy generation • Benefits and limitations 	08
Unit - III	<p>Hydro power, OTEC and geothermal energy</p> <ul style="list-style-type: none"> • Potential of hydropower, OTEC and geothermal energy in world and India. • Principle, generating methods, application and limitations • Benefits and limitations. 	08
Unit - IV	<p>Biomass Energy</p> <ul style="list-style-type: none"> • Biomass energy process: Thermo chemical (heat), direct combustion, Pyrolysis and biomass gasification. • Biochemical: Biomethanation (Anaerobic digestion): Alcoholic fermentation from sugar and starch crops and from cellulose. • Biophotolysis: (Biological hydrogen production) • Agrochemical: Vegetable oils and biodiesel 	08

	<ul style="list-style-type: none"> • Biomass production: Energy farming • Role of nanotechnology in biofuels • Benefits and limitations. 	
Unit - V	Nuclear Energy <ul style="list-style-type: none"> • Nuclear energy generation • Environmental issues of production, transformation and utilization associated such as radioactive waste, spent fuel; • Case study (Fukushima nuclear accidents) • Benefits and limitations. 	04
Unit - VI	Energy Sustainability <ul style="list-style-type: none"> • Need for energy efficiency • Energy conservation and sustainability • Action strategies for sustainable energy mix and management from a future perspective • National energy policy • Energy Development Agency (MEDA), • Save Energy Program by Maharashtra • Energy Audit: Definition, types and scope • energy subsidies and environmental costs 	08
Unit - VII	Energy, Environment and Society <ul style="list-style-type: none"> • Local and global impacts of energy use on the environment; • Construction of dams, environmental pollution); energy over-consumption and its impact on the environment, • Fossil fuel burning and related issues of air pollution • Social inequalities related to energy production, distribution and use. 	04

References:

1. McKibben, B. 2012. *Global Warming's Terrifying New Math*, Rolling Stone Magazine.
2. Craig. J. R., Vaughan, D. J., Skinner. B. J. 1996. *Resources of the Earth: Origin, Use, and Environmental Impact* (2nd edition). Prentice Hall, New Jersey.
3. Elliott, D. 1997. *Sustainable Technology. Energy, Society and Environment* (Chapter 3). New York, Routledge Press.
4. Rowlands, I. H. 2009. *Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies* in Debora L. Van Nijnatten and Robert Boardman (eds.), Canadian.
5. *Environmental Policy and Politics: Prospects for Leadership and Innovation*, Third Edition, Oxford University Press, 167-182.
6. Oliver, J. 2013. *Dispelling the Myths about Canada's Energy Future*, Policy: Canadian Politics and Public Policy, June - July.
7. Mallon, K. 2006. *Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision Making*, EarthScan.
8. Report on Save Energy Program (Financial assistance for Carrying Out detailed Energy Audit), by Maharashtra Energy Development Agency (MEDA) (Government of Maharashtra Institution).
9. G. D. Rai, *Non-conventional Energy Sources*, Khanna Publishers, ISBN: 8174090738.

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - VII
TITLE: ENVIRONMENTAL RESTORATION AND REMEDIATION
PAPER CODE: EVS3607

[CREDITS - 3]

Learning Objectives:

1. To study key ecological principles used for restoration of terrestrial and aquatic ecosystems.
2. To focus upon the role conservation and restoration play within the larger context of natural resource management.
3. To study restoration approaches that require careful assessment of alternatives constrained by complex ecological, sociological and political realities.

	Title and Contents	No. of Lectures
Unit - I	Fundamentals <ul style="list-style-type: none"> • Eco Restoration • Definition and principles • Significances • Guidelines • Principles of Restoration • Applications of Restoration Ecology 	08
Unit - II	Theoretical Basis for Understanding Restoration Potential <ul style="list-style-type: none"> • Concepts of resiliency and ecosystem change as they relate to aquatic and terrestrial systems. • Social, economic and political realities of restoration 	08
Unit - III	Restoration of Urban Ecosystem <ul style="list-style-type: none"> • Ponds, lakes, river banks, avenue trees • Biodiversity restoration through gardens, park, restoration of dumping grounds • Restoration of eco system on hills • Restoration of soil in urban areas, • Ground water resource - replenishment • Sewage or wastewater - recycling for supporting ecosystems • Case studies 	08
Unit - IV	Eco-restoration and Industrial Environment <ul style="list-style-type: none"> • Eco-restoration of mines (Open-cast), restoration of solid waste dumping sites • Improving aesthetics by partial restoration at industrial sites • Case studies 	08
Unit - V	Restoration of other Natural Habitats / Ecosystems <ul style="list-style-type: none"> • Mangroves • Grasslands • Wetlands 	08

	<ul style="list-style-type: none"> • Restoration of streams • Degraded forest patches • Coastal ecosystems • Case Studies 	
Unit - VI	Restoration Toolbox <ul style="list-style-type: none"> • 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 animals • Prevention of habitat loss • Species-area relationships • Network relationships and connectivity 	08
References: <ol style="list-style-type: none"> 1. Restoration of Nature by Prakash Gole. 2. Restoration Ecology the New Frontier - Edited by Jelte Van Andel and James Aronson - 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. Watershed Manual by B. K. Kakade (BAIF and LEAD India Publication). 5. Water Harvesting and Sustainable Supply in India by R. N. Athavale Centre for Environment Education, ISBN: 8170337526. 6. Watershed Hydrology by Peter Black, Lewis Publishers, ISBN1575040271. 7. Soil and Water Conservation Engineering by R. Suresh - Standard Publishers and Distributors, ISBN8180140008. 		

T.Y. B.Sc. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PAPER - VIII
TITLE: WASTE MANAGEMENT IN SMART CITIES
PAPER CODE: EVS3608

[CREDITS - 3]

Learning Objectives:

1. To understand importance of environmental approaches in smart cities.
2. To identify ICTs and application of advanced technologies in waste management.
3. To find unique approaches towards planning of future smart cities.
4. To develop critical understanding of natural systems and human efforts in waste management.
5. To identify problems faced by different countries in implementation of smart city concepts.
6. To design and implement research project in response to problems of waste management.

	Title and Contents	No. of Lectures
Unit - I	Introduction and Concept of Smart Cities <ul style="list-style-type: none"> • City as an Organism • Smart Sustainable City and Its Attributes • Smart Cities as Safe Cities • Technological Advancement and Waste Generation • Environmental Infrastructure and Quality of Life • Waste Management in Smart Cities of USA and Europe 	06
Unit - II	Environmental Approaches to Waste Management in Smart Cities <ul style="list-style-type: none"> • Principles of Waste Management • Reduction in Carbon Emissions • Concept of Sustainability and Waste Reduction • Consumption and Ecological Footprint • Climate Neutral Urban Waste • Management Green Buildings and Practices 	06
Unit - III	Waste Management in Smart Cities <ul style="list-style-type: none"> • Energy Simulation (Waste to Energy) • Automated Landfill Management • Integrated Asset Management Solutions • Process Automation • Integrated Command and Operations Centre • Geospatial Dashboard 	06
Unit - IV	Intelligent Waste Management Systems for Smart Cities Principle and Applications of following: <ul style="list-style-type: none"> • Nano-Filtration, Ion exchange, Reverse Osmosis • Incineration of Wastes • Electrolysis, Gas and Vapour Control Systems • Catalytic Converters Innovative Engineering Designs in Waste Treatment	06

	(Solid, Air, Wastewater etc.)	
Unit - V	Information and Communication Technology in Smart Management <ul style="list-style-type: none"> • Comprehensive Mobility Plan • Application of GIS Technology, Networking • Automated Waste Collection and Transportation • Use of Electronic / Radio Frequency Tags • Pollution Sensors and Sensor-Based Sorting • Smart Pneumatic Waste Conveyance System • Internet of Things and GSM Technology • Real Time Awareness and Control 	06
Unit - VI	Approaches for Waste Management <ul style="list-style-type: none"> • Green Chemistry and Waste Treatment • Nanotechnology in Waste Management • Hazardous Waste Management in Smart Cities • Fuel Cell Implementation in Waste Management • Low Carbon/Neutral Urban Structure • Life-Cycle Assessment of Products 	06
Unit - VII	Waste Management Governance and International Efforts <ul style="list-style-type: none"> • Policy Needs and Review • Role of United Nations • Role of International Agencies and Court • Smart City Governance • Sustainable Waste Management- Holistic Engagement • Technology Transfer and Technical Training 	06
Unit - VIII	Waste Management Practices in Asia India: <ul style="list-style-type: none"> • Mission of India and Plans for Smart Cities • Current Practices in Top Ten Cities of India • Business Opportunities and Challenges Asian Countries: <ul style="list-style-type: none"> • Smart Cities of Asia and Practices, Case Studies • Solid Waste Management in Asian Countries • Sustainable Waste Management 	06

References:

1. Andrea Caragliu, Chiara Del Bo and Peter Nijkamp (2009): Smart Cities in Europe 3rd Central European Conference in Regional Science - CERS.
2. Anthony M. Townsend (2014) Smart Cities-Big Data, Civic Hackers, and the Quest for a New Utopia. W. W. Norton & Company, Reprint Edition.
3. Brook D. (2013): A History of Future Cities, W.W. Norton & Company, New York.
4. Developing Integrated Solid Waste Management Plan (2009): Volume 4: ISWM Plan United Nations Environment Programme.
5. Hill, D. (2013): On the Smart City: Or, A 'Manifesto' for Smart Citizens Instead. City of Sound.

6. Jonathan F. P. Rose (2016): *The Well-Tempered City: What Modern Science, Ancient Civilizations, and Human Nature Teach Us about the Future of Urban Life* Harper Wave?
7. Leonidas G. Anthopoulos (2017): *Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick?* Springer; 1st Edition.
8. Moore, S. (2006). *Forgotten Roots of the Green City: Subsistence Gardening in Columbus, Ohio, 1900-1940*. *Urban Geography*, 27 (2): 174-192.
9. *Planning a Sustainable Future for the City of London. Waste Strategy, 2013-2020*
10. Richardson, R.B. (2013): *Building a Green Economy: Perspectives from Ecological Economics*. Michigan State University Press, East Lansing, Michigan.
11. Robinson, J. (2002): *Global and World Cities: A View from Off the Map*. *International Journal of Urban and Regional Research*. 26, 531-554.
12. *Scientific American Editors (2014): Designing the Urban Future: Smart Cities*.
13. Shahrokni, H.; van der Heijde, B.; Lazarevic, D.; Brandt, N. (2014): *Big Data GIS Analytics towards Efficient Waste Management in Stockholm*. 2nd International Conference on ICT for Sustainability.
14. Smart Cities Council (2015) *Smart Cities Readiness Guide. The Planning Manual for Building Tomorrow's Cities Today*.

T.Y. B.SC. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PRACTICAL - IV
PAPER CODE: EVS3611

[CREDITS - 2]

Practicals Based on EVS3601: Waste Treatment Technology

1.	Qualitative and quantitative estimation of municipal solid waste.
2.	Demonstration of working of incineration / pyrolysis with video.
3.	Estimation of colour by using spectrophotometer
4.	Design of ETP / STP by using given data.
5.	Estimation turbidity of water sample by treatment of activated charcoal.
6.	Estimation of chemical oxygen demand from given waste water sample
7.	Estimation of biological oxygen demand from given waste water sample
8.	Determination of plant available heavy metals by DTPA extraction method.
9.	Study of jar test for waste water treatment.
10.	Measurement of equivalent noise level by SLM from silent, industrial, residential and commercial zones.
11.	Estimation of soil phosphate from farmlands.
12.	Demonstration and working of GM counter, scintillation counter. (Visit to Chemistry Department, SPPU)
13.	Visit to hazardous waste/biomedical waste treatment facility
14.	Visit to transfer station / dumping site
15.	Colour removal by using UV/ Ozone radiation

Practicals Based on EVS3602: Wildlife Biology and Conservation

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.	To find out 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

Practicals Based on EVS3603: Environment Impact Assessment and Management

1.	Current EIA notifications
2.	EIA process with examples
3.	Problems 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.	Environmental and social survey based on questionnaire of the impact area
7.	Case studies of EIA
8.	Preparation of EMP

T.Y. B.SC. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PRACTICAL - V
PAPER CODE: EVS3612

[CREDITS - 2]

Practicals Based on EVS3604: Environmental Governance and Ethics	
1.	Survey on field conditions and drawbacks associated with selected environmental law
2.	Visit to regional pollution control board
3.	Preparation of draft report for changes and drawbacks associated with selected law
4.	Understanding process of public interest litigation through court
5.	Preparation of report on major judgement by courts on selected law
6.	Report preparation on understanding the process of filing environmental case
7.	Law specific case study on violation in selected area
8.	Preparation of documentary on environmental issues and legal aspects associated with it
9.	Legal survey based on questionnaire to understand environmental governance
Practicals Based on EVS3605: Environmental Toxicology, Health and Safety	
1.	Testing the bacteriological quality of drinking water
2.	Determination of MPN from drinking water resource for potability
3.	Effect of toxicants and wastewater on seed germination
4.	Estimation of LC ₅₀ / LD ₅₀ value of metal on aquatic organisms
5.	Estimation of LC ₅₀ / LD ₅₀ value of industrial effluent on aquatic organisms
6.	Study of oligodynamic effects of metals sheets / metal salts on microorganisms
7.	Isolation of microbial pathogen from waste water
8.	Visit to toxicity testing laboratory and research center
9.	Estimation of polyphenol content from plants exposed to pollution
10.	Estimation of protein / proline from given plant / animal tissue sample
11.	Isolation of bacteria from polluted sites, e.g. hydrocarbon and pesticide contaminated, mining areas
Practicals Based on EVS3606: Energy and Environment	
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
7.	Study of applications of solar energy e.g. solar cooker and water heater / photovoltaic cells.
8.	Study of electric storage system - battery
9.	Estimation of calorific value from given biomass samples
10.	Study of energy audit process: Formats and Survey
11.	Visit to energy park.
12.	Visit to nuclear power plant / nuclear energy research center, BARC, Mumbai, Jaitapur etc.
13.	Visit to biogas / biogasifiers / biodiesel plant

Practicals Based on EVS3607: Environmental Restoration and Remediation	
1.	Study of morphological and structural characters of plants used in phytoremediation.
2.	Isolation of microbes from contaminated soils and analysis of their potential for bioremediation using any contaminated site / s
3.	Analysis of key parameters from inlet and outlet of phytoremediation bed using waste water treatment
4.	Visit to restoration site.
5.	Study of soil reclamation techniques by using pot culture
6.	Estimation of plant available sulphur from soil.
7.	Preparation and analysis of technosoil for restoration of contaminated sites.
8.	Comparative analysis of soils / water collected from various restored sites
Practicals Based on EVS3608: Waste Management in Smart Cities	
1.	Questionnaire survey on current practices followed in proposed smart city
2.	Survey on problems involved in implementation of smart city
3.	Study of simple sensor based analysis of pollutants/design circuit diagram
4.	Study of carbon sequestration potential of smart city
5.	Study of online softwares and information& communication technology (ICT) for study of smart city
6.	Study of mobile apps for implementation of services for smart city
7.	Study of Google Earth for getting useful information in services for smart city
8.	Preparation of documentary for proposed for smart city, Pune
9.	Visit to smart building/green building nearby city area
10.	Study of automated landfill management practice
11.	Study of nanotechnology for pollution reduction
12.	Electrocoagulation as tertiary treatment for wastewater treatment

T.Y. B.SC. (ENVIRONMENTAL SCIENCE) SEMESTER - VI
ENVIRONMENTAL SCIENCE PROJECT
CODE: EVS3613

[CREDITS - 2]

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.