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

Syllabus

for

M. Sc. (Environmental Science) Part II

(Semester-III and Semester-IV)

[Pattern 2019]

from Academic Year

2020-21

Program Structure for M.Sc. in Environmental Science

FERGUSSON COLLEGE PUNE				
M.Sc Environmental Science Program structure 2019-20				
M.Sc Course structure and credits distribution (20 credits per semester, Total 80 credits)				
Semester	**Course code**	**Course Title**	**Course**	**No of Credits**
Sem- I	EVS4101	Environmental Biology	T Core-1	4
	EVS4102	Environmental Chemistry	T Core-2	4
	EVS4103	Environmental Geo and Atmospheric science	T Core-3	4
	EVS4104	Practical 1	P Core-1	4
	EVS4105	Practical 2	P Core-2	4
Sem- II	EVS4201	EIA and Environmental Audit	T Core-4	4
	EVS4202	Water and Wastewater Treatment Technology	T Core-5	4
	EVS4203	Biodiversity, Forestry and Conservation	T Core-6	4
	EVS4204	Practical 3	P Core-3	4
	EVS4205	Practical 4	P Core-4	4
Sem- III	EVS5301	Environmental Statistics	Special -1	4
	EVS5302	Remote Sensing and GIS	Special -2	4
	EVS5303	Climate Change and Sustainability	Departmental	4
	EVS5304	Environmental Issues	General	
	EVS5305	Environmental Sustainability	Mooc	
	EVS5306	Summer Training	P Special -1	4
	EVS5307	Practical 5	P Special -2	4
Sem- IV	EVS5401	Environmental Law Ethics Policies	Departmental	4
	EVS5402	Environmental Management Systems	General	
	EVS5403	Life Cycle Assessment	Mooc	
	EVS5404	Restoration and Watershed	Departmental	4
	EVS5405	Green Technologies	General	
	EVS5406	Ecology and Society	Mooc	
	EVS5407	Environmental Health, Toxicology and Safety	Departmental	4
	EVS5408	Energy Resources and Technologies	General	
	EVS5409	Waste to Energy Conversion	Mooc	

	EVS5410	Practical 6	P Special -3	4
	EVS5411	Dissertation	P Special -4	4

S.Y. M.Sc. Semester III		
Title of the Course and Course Code	**Environmental Statistics (EVS5301)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe concept of population and sample in Environmental statistics. Distinguish between different ways used for data sampling.	
CO2	Classify data in the form of a frequency distribution table. Articulate variables in diagrammatic and graphical form.	
CO3	Compute measures of dispersion with the help of suitable tools. Apply suitable softwares for assessment of environmental variables	
CO4	Identify discrete, continuous distributions for probability assessment. Analyse probabilities with the help of different distribution methods.	
CO5	Evaluate Environmental datasets and calculate its central component.	
CO6	Construct different indices by using tools of statistics.	

Units	Contents
Unit I	**Foundation of Environmental Statistics** ● Concept of Population, Sample, variable, parameters, random variable and parameters of interest ● Sampling, Types of random and non-random sampling ● Experiment design ● Concepts of statistical inference, sample selection ● Concept of data, its types; Discrete and continuous data, frequency and non-frequency data ● Frequency distributions ● Data presentation methods; Diagrammatic methods Graphical methods

Unit II	**Measure of Central Tendency** ● Mean ● Median ● Mode ● Geometric mean. ● Harmonic mean ● Partition values **Measure of Dispersion** ● Range ● Variance and standard deviation ● Coefficient of variation ● Skewness and Kurtosis **Probability** ● Concept of Probability and distribution models; terms and definitions ● Normal distribution and its properties ● Binomial Distribution ● Poisson Distribution ● Calculations of probabilities for different events
Unit III	**Correlation & Regression** ● Concept of Correlation and Regression ● Linear and non- linear regression models ● Estimating coefficients of correlation and regression ● Calculation of fitted values and residuals **Test of Inference** ● Concepts of Hypothesis testing, p-value ● Concept of Parametric and non-parametric test ● Introduction to small sample and large sample test ● Applications of Chi- square test, t test, Z test ● One way & two-way ANOVA ● Concept & applications of PCA
Unit IV	**Concept of Mathematical Model** ● Exponential, logistic models for population growth ● Lotka-Voltera Prey and predator model ● Box model ● Gaussian plume dispersion model ● Point source stream model Leslie's matrix model **Applications** ● Statistical power and sample size ● Analysing and dealing with outliners ● Indices used for various Environmental variables ● Introduction to software used for Environmental data analysis

Reference Books

- Barnett Vic (2004) Environmental Statistics: methods and applications.
- Ott, Wayne R. (1995) Environmental Statistics and data analysis.
- Zar, Jerrold H. (1997) Biostatistical Analysis. Prentice Hall (India)
- Nychka, Douglas and Piegorsch Walter W (1998) Case studies in Environmental Statistics.
- Manly Bryan F.J. (2001) Statistics for Environmental Science and Management.
- Walpole R. and Myem R. (1993) Statistics for engineers and scientists.

Title of the Course and Course Code	**Remote Sensing and GIS (EVS5302)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basics of Electromagnetic radiation and Spectrum. Describe basic concepts, principles and processes of Remote sensing and GIS.	
CO2	Discuss satellites in space and their applications.	
CO3	Demonstrate map projection methods to understand its importance and limitations. Apply the techniques to address real life field issues using different softwares.	
CO4	Compare Raster data, Vector data in GIS to recognize its role in generating information about different features on the earth and 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 by using geo-processes and functions. Collect GIS data to study recent advances.	

Units	Contents
Unit I	**Basics of Remote Sensing** ● Introduction to Remote Sensing ● Remote Sensing Process ● Physics of Radiant Energy ● Electromagnetic Radiation and Electromagnetic Spectrum ● Energy Source and its Characteristics ● Atmospheric Interactions with Electromagnetic Radiation Atmospheric Properties ● Absorption of Ozone ● Atmospheric Effects on Spectral Response Patterns ● Energy Interactions with Earth's Surface Materials ● Energy Matter Interaction: Absorption, Emission, Transmission, Emission Spectral Reflectance Curves or Spectral Signature

	Platforms & Sensors ● Introduction ● Sensor Types: Active and Passive ● Sensor Parameters Spatial Resolution Spectral Resolution Radiometric Resolution ● Imaging Sensor Systems ● Multispectral Imaging Sensor Systems Thermal Sensing Systems ● Microwave Image Systems ● Platforms ● Airborne remote sensing Spaceborne remote sensing ● Satellites in the Space ● Open Data Satellites ● Commercial Satellites ● Weather Satellites ● Geodesy Satellites ● Ocean Satellites
Unit II	**Visual Image Interpretation** ● Introduction ● Image Understanding and Interpretation ● Human Vision ● Interpretation elements ● Stereoscopic vision **Digital Image Processing** ● Introduction ● Principles of Image classification ● Image Classification Process Pre-processing ● Geometric Correction Radiometric Correction Atmospheric Correction ● Image Registration ● Image Enhancement Techniques Spatial Filtering Techniques ● Low Pass Filters High Pass Filters ● Filtering for Edge Enhancement Image Transformations ● Image Classification: Supervised and Unsupervised ● Accuracy assessment
Unit III	**Basics of GIS** ● Definition and Objectives of GIS, Concept of space and time, components of GIS, basic entities of GIS: line point and polygon ● Map Projection: Conical, Azimuthal and Cylindrical. LCC Projection, UTM and Polyconic projections. ● Types of datum **Data Structures in GIS** ● Spatial data: Raster data, Vector data, comparative overview. ● Non-spatial data - Hierarchical, Network and relational data.

	• Concept and type of topology
Unit IV	**Spatial Analysis** • Vector based: Overlays operations- point in polygon, line in polygon, polygon in polygon; • Single layer operations and Multilayer operations. • Raster based: Map algebra, Grid based operations. • Buffering, Network Analysis, Terrain Analysis, Digital Terrain models and generation of Thematic maps. **Applications of RS and GIS** • Land Use Land Cover (LULC) changes • Natural hazards and hazard management: Floods, landslides and other hazards • Monitoring water quality and soil quality • Mineral exploration, • Lithological and structural mapping • Use of GIS to represent environmental status and highlight Environmental issues

Reference Books

Ebooks

- Alan S. Belward and Carlos R. Valenzuela (1991) Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries
- M. Anji Reddy (2008) Textbook of Remote Sensing and Geographical Information Systems Third Edition
- 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.
- Fundamentals of Remote Sensing. A Canada Centre for Remote Sensing Remote Sensing Tutorial

Books

• Bhatta (2008) Remote Sensing and GIS, Oxford University press.

• Lillisand, T. M. and Keifer, R. W. (1990): Remote Sensing and Image interpretation, John Willey and Sons, New Delhi.

• Joseph G. (2004): Fundamentals of Remote Sensing, Universities Press, Hyderabad.

• Burroughs, P. A (1986): Principles of Geographical Information Systems for land Resource Assessment, Oxford University Press.

• Gupta, R. P. 2003. Remote sensing geology, Springer, New York

• Barrett, E. C. and Curtis, L. F.1999. Introduction to environmental remote sensing. Chapman and Hall

• Sabins, F. F. (1996): Remote Sensing: Principles and Interpretation, W. H.

Freeman and Company, San Francisco
- Jensen, J. R. (2005): Introductory Digital Image Processing, Prentice Hall, New Jersey
- Drury, S. A. (2001): Image Interpretation in Geology, Blackwell, Oxford
- Campbell, J. (2002): Introduction to Remote Sensing, Taylor & Francis, London
- Anji Reddy, M. (2008): Textbook of Remote Sensing and Geographic Information System, B.S. Publication, Hyderabad.
- Haywood, Ian (2000): Geographical Information Systems, Longman
- Chang, K. T. (2008): Introduction to Geographic Information Systems, Avenue of the Americas, McGraw-Hill, New York
- Longley, P. A., Goodchild, M. F., Maguire, D. J., Rhind, D. W. (2002): Geographical Information Systems and Science, John Wiley & Sons, Chichester
- Lo, C. P., Yeung, A. W. (2002): Concepts Techniques of Geographical Information Systems, Prentice-Hall of India, New Delhi
- Korte, G. B. (2001): The GIS Book, Onward Press, Bangalore
- Demers, M. N. (2000): Fundamentals of Geographic Information Systems, John Wiley and Sons, New Delhi
- Burrough, P. A. and McDonnell, R. A. (2000): Principles of Geographical Information Systems, Oxford University Press, New York

Title of the Course and Course Code	**Climate Change and Sustainability (EVS5303)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify, list environmental, social, and economic impacts of anthropogenic activities and required sustainability framework for mitigation.	
CO2	Discuss the anthropogenic and natural drivers of climate change and future developments aspects for sustainability. Outline scope, importance, and opportunities for climate change and sustainability studies.	
CO3	Calculate environmental impacts for different development projects by using common methodologies.	
CO4	Analyze the impacts of climate change and compare with future goals of sustainability. Compare different policies and agreements regarding climate change and developmental goals.	
CO5	Evaluate the impacts of climate change and sustainability by appropriate tools and techniques.	
CO6	Compile the data and prepare reports by using different methods about climate change and sustainable practices.	

Units	Contents
Unit I	**Part I: Climatic Systems and Variations** ● Global Climate System ● Causes for Modern Climate Change ● Internal Variability: Ocean-Atmosphere Variability, Ocean Currents ● External Climate Forces: Greenhouse Gases, Orbital Variations, Solar Fluctuations, Volcanism, Plate Tectonics ● Evidence and Measurement of Climate changes **Part II: Consequences and Challenges** ● Impacts on Life, Vegetation, Fauna ● Glaciers and Ice Sheets Melting ● Sea Level Changes ● Economics of Climate Change ● Climate Change and Water Scarcity ● Coastal Ecosystem and Vulnerability ● Threats to Forest and Biodiversity ● Agriculture and Food Security ● Energy Generation and Climate Change Mitigation
Unit II	**Part I: Confronting Climate Change: Policies and Efforts** ● India: National Action Plan on Climate Change (NAPCC) ● State Action Plan on Climate Change (SAPCC) ● National Adaptation Fund on Climate Change (NAFCC) ● India's Post-2020 Climate Goals ● Climate Change Action Programme (CCAP) ● National Carbonaceous Aerosols Programme (NCAP) ● Long Term Ecological Observatories (LTEO) Programme
	● Clean Development Mechanism (CDM) ● Extreme Events and Disasters ● International Efforts ● UNFCCC and Conference of the Parties ● Special Reports by IPCC ● Kyoto Protocol and Agreements ● Copenhagen Conference ● Paris Agreement ● Findings and Efforts by NASA and ISRO **Part II: Mitigation Approaches in Climate Change** ● Climate and Weather Statistics ● Climate Change Modelling ● Carbon Emissions Reduction Technologies ● Climate Change Research ● Climatology Journals and Top Institutions ● Governance for Climate Change ● Clean Development Mechanism ● Technology Options Fuel Switching and Carbon Sequestration ● The Economics of Carbon Mitigation: Integrated Assessment Models

	(IAM) ● Regional, National and International Experiences
Unit III	**Part I: Concepts in Sustainable Development** ● Origins of Sustainable Development: Definition, Evolution and Principles, Brundtland Report ● Strategies for Sustainable Development ● Sustainability and Human Development ● Green Politics and Sustainable Development ● Cultural Elements in Sustainable Development Frameworks ● Human Cantered Designs in Sustainability ● The 2030 Agenda for Sustainable Development **Part II: Sustainable Development Goals and Issues** ● UN Sustainable Development Knowledge Platform ● Tools for Sustainable Development ● Sustainable Development Goals ● Communicating the Sustainable Development Goals ● Criticisms in Sustainability ● Insubstantial Stretching of the Term ● Cross-Cutting Issues ● Women and Gender Equality ● Education and Sustainable Development ● Implementation, Support and Tracking Progress ● Public Engagement in Sustainable Development
Unit IV	**Part I: Environmental Conservation and Sustainability** ● Technical Skills in Environment and Sustainability ● Vulnerability, Adaptation and Livelihoods ● Preservation of Biological Diversity ● Sustainable Forest Management ● Environmental Governance and Sustainability ● Environmental Economics and Sustainability ● Water Conservation and Sustainable Development ● Urbanization and Sustainable Cities ● Challenges in Energy, Food and Agriculture **Part II: New Developments in Sustainability** ● Appropriate Technology and Sustainability Science ● Consumption and Production Patterns ● Sustainable Transport ● Corporate Sustainability ● Sustainability Metrics and Indices ● Ecological and Carbon Footprint for Sustainability Measurement ● Sustainability Measurement and Reporting Tools

	• Success Stories of Strategies in Sustainability • Sustainability in Policy Design

Reference Books

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

Title of the Course and Course Code	**Environmental Issues (EVS5304)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Outline the important local and regional environmental issues.	
CO2	Discuss reasons, practices behind important environmental issues at the global, national and local level.	
CO3	Calculate the impacts of the issues by using different methods and classify unique approaches towards the solution of the issues in different societies.	
CO4	Compare the practices followed for solution of environmental issues in different societies and relate them with national practices.	
CO5	Compare and evaluate the strengths of advanced techniques and traditional practices to minimize impacts on the environment.	
CO6	Prepare a plan for identification of local environmental issues and collect data to write a report about the solution of these issues.	

Units	Contents
Unit I	**Part I: Global Environmental Issues** ● Ozone Layer Depletion ● Acid Rain and Its Spread ● Desertification and Expansion ● Greenhouse Effect and Global Warming ● Climate Change and Current Issues ● Energy Crisis and Issues ● Genetically Modified Organisms ● WTO and Environmental Issues ● Species Loss and Human Impacts **Part II: Global Environmental Issues** ● E-Wastes and Global Generation ● Food Crisis and Population ● Biological Warfare and Future Threats ● Eco-Terrorism and Issues ● Issues Related to Shipping ● Water Crisis and Future Conflicts ● Population Explosion and Resource Crunch ● Wastelands and Degradation
Unit II	**Part I: International Efforts** ● Sustainable Development Goals and Solutions ● Clean Development Mechanism ● Carbon Emissions and Future Targets ● Carbon Credits and Its Implementation ● Carbon Sequestration and Programmes ● Green Politics and Issues ● Role of IUCN and UNEP ● Important International Agreements **Part II: Environmental Issues in India** ● Soil Erosion and Impacts on Production ● Alkaline and Saline Soils ● Industrial and Vehicular Air Pollution of Indian Cities ● Water Quality Degradation of Indian Rivers ● Groundwater Pollution and Its Consequences ● Municipal Solid Wastes and Conflicts ● Issues with Slums and Environmental Health ● Droughts and Floods in India ● Eutrophication Issues of Major Aquatic Ecosystems ● Dams and Displacement Issues
Unit III	**Part I: National Efforts to Curb Issues** ● Citizen Participation in Environmental Decisions ● Environmental Information System Network ● Right to Information and Environment Protection

	● Policies and Laws on Environmental Protection ● Ganga Action Plan and Recent Programmes ● Interlinking of Rivers: Plan and Implementation ● Strategies under Disaster Management Plan ● Wasteland Development Programme ● Fly Ash Utilization Policy ● Rainwater Harvesting and Its Implementation **Part II: Environmental Issues and Genesis of Movements** ● Genesis of Environmental Movements in India ● Chipko Movement and Its Message to World ● Narmada Bachao Andolan and Outcome ● Developments in Save Silent Valley Movement ● Tehri Dam Conflict and Current Situation ● Indian Case Studies to Solve Issues ● Environmental Movements in Developed Countries
Unit IV	**Part I: Practices Followed in Environmental Conservation** ● Environment as Core Part of Sustainability ● Conservation for Economic and Social Upliftment ● Vulnerability, Adaptation and Livelihoods Security ● Conservation of Biodiversity and Forests for Survival ● Water Conservation as Important Constituents of Ecosystems ● Conservation in Smart Cities ● Future Energy, Food, Agriculture Security and Conservation ● Technical Skills Required for Environmental Conservation **Part II: Current International Developments** ● Need for Appropriate Technologies ● International Environmental Governance ● Polluter Pays Principle and Legal Liabilities ● MNCs/TNCs and Corporate Social Responsibility ● Real Time Monitoring of the Issues ● Ecological and Carbon Footprint Calculations ● Life Cycle Assessment Studies for Organisations ● Sustainability Measurement and Reporting Tools ● Newer Approaches in Human Development Success Stories of Mitigating Environmental Issues

Reference Books

- Environmental Science by Santra S. C., New Central Book Agency (P) Limited (2001).
- Environmental Chemistry by Sharma B. K., Goel Publishing House, Meerut (1997).
- Environmental Chemistry by De A. K, New Age International (P) Limited (2017).
- Environmental Issues in India: A Reader by Rangarajan, Pearson Education India (2006).
- Climate Change and Environmental Issues by Singh N. and Thakur A. K., The Energy

Resources Institute (TERI) (2016).
- Global Environmental Issues by Frances Harris, Wiley-Blackwell, (2012).
- An Introduction to Global Environmental Issues by Pickering K., Routledge (1994).
- Environmental Science by Daniel D. Chiras, Jones and Bartlett Publishers (2001).
- Environmental Science by Y.K. Singh, New Age International Private Limited; First edition (2006).
- Development, Ecology and Climate Change: Issues and Challenges: Volume 1 by Mohinder Kumar Slariya Createspace Independent Publication; (2015).
- Environmental Studies and Ethics by Gouri Suresh, U. S. Hampannavar I K International Publishing House Pvt. Ltd; (2009).
- Environmental Conservation and Life (Hindi) by Nisha Maharana, Agrawal Publications; (2017).
- Environmental Issues in India: A Reader, by Rangarajan, Pearson Education India; (2006).
- The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming by Roger Pielke Basic Books; (2010).
- Climate Change and Environmental Science by S. C. Bhatia Agrotech Press; (2012).
- Environmental Management by Ajith Sankar Oxford University Press; (2015).
- Principles of Environmental Science: Inquiry and Applications (SIE) by William Cunningham and Mary Cunningham McGraw Hill Education; (2017).
- Principles of Environmental Science and Engineering by Rao P. Venugopala, Prentice Hall India Learning Private Limited; (2006).
- Various Case Studies from Leading Journals of World.

EVS 5305: **Environmental Sustainability (4 credits)**

- It is a MOOC course please refer http://ugcmoocs.inflibnet.ac.in/ugcmoocs/courses.php for course details.

Title of the Course and Course Code	**Summer Training (EVS5306)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Outline the concepts, basic scientific principles of different environmental parameters. Identify and tabulate the tasks to be performed as part of summer training in an organization.	
CO2	Explain techniques used in working for environmental management during training.	
CO3	Implement theoretical, practical knowledge gained from curriculum in the field and gain skills for environmental management and conservation.	
CO4	Analyse environmental variables with help of different tools, systems and apply them on field.	

CO5	Measure the effectiveness of conservation action plans for a particular region.
CO6	Prepare a project report. Propose an effective treatment method for better management of the environmental issues.

The world of today is full of competition in each and every field. In order to cop-up with the needs of the time it has become necessary to prepare ourselves in tune with the norms and practices accepted and implemented across the globe. As such, one of the important aspects is to add a value to a postgraduate degree by imparting a knowledge based and hands-on experience training to the students.

Guidelines:

- Students are expected to undertake the field work or industrial training for acquiring skills and hands on experience in the field of Environmental Science.
- Teachers of the department will be monitoring the progress of students by interaction with the students and concerned authority of training institute / organisation.
- After completion of the training, students need to submit the training report and present their work in the department.
- Student will be considered to have "Completed" the Internship/Industrial Training upon the submission of certificate of completion, duly signed and sealed, from the Organization where the candidate worked during the Internship period.

Reference: CREDIT SYSTEM (CS) For SEMESTER PATTERN Post Graduate Programs Handbook (Updated Version) Prepared by Professor Vilas Kharat and Dr. V. B. Gaikwad, Savitribai Phule Pune University, Pune.

Title of the Course and Course Code	**Practical 5 (EVS5307)**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Outline distribution of frequencies in sample.	
CO2	Classify environmental data with the help of suitable statistical methods and illustrate it by using software	
CO3	Illustrate the spatial data using attribute query or spatial query. Use vector data layers to form maps.	
CO4	Analyse geo-spatial datasets. Relate the spatial and non-spatial data to create	

	links between them. Explain the satellite data visually and digitally using softwares.
CO5	Review and evaluate the impacts of the local and regional climatic system, carbon footprint and sustainability.
CO6	Collect long term data for solutions to the environmental issues and prepare a final report with scientific techniques. Develop practical skills in using RS and GIS softwares.

Practicals based on EVS5301: Environmental Statistics

1. Classification of data and preparation of frequency distribution tables
2. Problem based on diagrammatic representation of data
3. Graphical data representation by Histogram and frequency polygon
4. Calculating measures of central tendency for the given data
5. Applications of partition values and problems based on it
6. Calculating variance, standard deviation and coefficient of variation for given data.
7. Problems based on probability distribution models
8. Use of statistical tables, analysing level of significance, p-value
9. Computing correlation coefficient and testing its significance.
10. Computing simple linear regression. Plotting scatter diagram and regression line
11. Comparison between means of two independent samples - Paired t-test
12. Method of analysis of variance: one way and two- way classification
13. Introduction to software used in Environmental data analysis

Practicals based on EVS5302: Remote Sensing and GIS

1. Introduction to Visual interpretation of satellite Image with FCC and True colour composite.
2. Overview of softwares as QGIS, ArcGIS, Global Mapper, Erdas Imagine etc.
3. Introduction to GPS and its handling, spatial data acquisition and import.
4. Georeferencing using Toposheet/Satellite image/GPS and subset creation.
5. Image classification using supervised, unsupervised and hybrid methods.
6. Ground truthing: A Field survey visit.
7. Accuracy assessment of classified satellite image using ground truth data.
8. Preparation Vector data as Point, Line, polygon and Vector layers creation.
9. Geoprocessing of Spatial data: Buffering, Clip, Crop.
10. Creation and linking of spatial and non-spatial data.
11. Preparation of Digital Elevation Model (DEM).
12. Map composition with Raster data and Vector data.

Practicals based on EVS5303: Climate Change and Sustainability

1. Measurements for the impact of environmental stress conditions on plants
2. Estimation of carbon sequestration by using different methods
3. Studies on plants facing pollutants from selected areas
4. Statistical analysis of the secondary data collected from metrological sites
5. Measuring the impact of climate change in a vulnerable population

6. Impacts of extreme events in selected areas: A case study
7. Use of RS and GIS technology in mapping climatic changes
8. Measurement of ozone concentration and analysis of the data
9. Preparation of documentary on climate change and sustainability practices
10. Preparation of documentary on sustainable practices of an organization or agency or village area
11. Studies on measurements of sustainable farming practices
12. Questionnaire survey based on online platforms and analysis
13. Measurement and analysis of the data by using online software about sustainability
14. Measurement of life cycle analysis by using online software
15. Measurement of sustainability by using innovative approaches and designs
16. Measurement of carbon footprint and ecological footprints by using online software
17. Analysis of the data and presentation of the data by using different software

Practicals based on EVS5304: Environmental Issues and Solutions

1. Analysis of fly ash for various parameters
2. Effect of fly ash as on plants, laboratory-based experiments
3. Analysis of artificially prepared and natural solid waste leachate for selected wastewater parameters
4. Questionnaire survey based genetically modified organisms by using Google forms
5. Study of acid rain solutions and its impact on physical materials
6. Effect of acid rain solution on plants/seed germination study
7. Demand for ecofriendly products available in market
8. Online softwares analysis for relation between drought and groundwater quality
9. Online softwares for mapping of carbon footprint and ecological footprint
10. Preparation of documentary for environmental issues of a specific city
11. Estimation of organic carbon from given plant sample
12. Use of online software for trajectory analysis
13. Study of carbon sequestration in laboratory by addition of artificial agents
14. Participation in at least one activity run by international NGO to solve environmental issues
15. Study on issues associated with dams
16. Study on issues of vehicular pollution on city on physical and biological areas
17. Understanding and Mapping for degradation of river ecosystem
18. Estimation of rainwater harvesting potential of Fergusson College campus
19. Preparation of video documentary of the issues faced by nearby populated areas

Note: Any other equivalent practical

S.Y. M.Sc. Semester IV		
Title of the Course and Course Code	**Environmental Law Ethics Policies (EVS5401)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify important provisions of Environmental laws in India and international agreements.	
CO2	Discuss about important provisions of environmental laws in India and international agreements. Explain the differentiation in policies of different societies.	
CO3	Carry out critical examination of the different legal case studies from India and abroad. Solve the examples based on provisions of the environmental laws.	
CO4	Explain the role of the constitution and different administrative mechanisms.	
CO5	Review the Environmental ethics and justify challenges associated with it.	
CO6	Compile legal requirements of policies related to different natural resources.	

Units	Contents
Unit I	**Environmental Law and Policy** ● Introduction to Law, Policy: Meaning, Basic difference and Importance. ● Indian Constitution and Environment ● Role of Constitution in Environment Protection, ● Fundamental Rights and Duties, Article 48A, 51A (g) and 58A ● Precautionary and Polluter pays principles; Absolute and Strict liability **Principles and Frameworks** ● Stockholm declaration ● Nairobi Declaration ● Rio Conference ● Kyoto Protocol ● World Summit on Sustainable Development (Rio + 10) ● Paris Agreement, CoP ● International Conventions: Convention on Biological Diversity, Convention on Climate Change, Ramsar Convention, Vienna Convention, Basal convention ● Role of UN authorities in protection of Global Environment
Unit II	**Environmental Laws in India: Anti-Pollution Acts** ● The Water (Prevention and Control of Pollution) Act,1974 ● The Air (Prevention and Control of Pollution) Act,1981 ● The Environment (Protection) Act,1986 ● The Public Liability Insurance Act, 1991

	● The National Environmental Tribunal Act, 1995 **Environmental Laws in India: Conservation Acts** ● Indian Forests Act (Revised),1982 ● The Indian Wildlife (Protection) Act,1972 amended 1991 ● The Biological Diversity Act, 2002 ● National Green Tribunal Act,2010 ● Public Interest Litigation (PIL)
Unit III	**Rules and Regulations** ● Hazardous waste management and handling rules ● Solid waste management and handling rules ● Biomedical waste regulations ● Plastic waste management regulations ● Noise Pollution Rules ● E-Waste management rules **Consent applications and forms** ● Introduction to consent applications and categories; Process for new application and amendments ● Environment statement form ● Water cess form ● MSW applications ● Hazardous waste applications ● Bio-medical waste applications ● Plastic regulation application ● E-waste application
Unit IV	**Policies** ● National Environmental Policy ● National Forest Policy ● National Water Policy ● Policies on Renewable and Non-renewable energy resources ● Environmental Status report **Environmental Ethics** • Introduction and concept of Environmental Ethics • Ethical theories applied to the Environment • The ethical dilemma: Environmental ethics and population, ethics and pollution • Human life and its Environment: art of ethics and an ethical dilemma • Challenges of World Environmental ethics

Reference Books

- P. Leelakrishnan: Environmental Law in India, Lexisnexis, 2010.
- Alexander Gillespie: International Environmental Law, Policy and Ethics. Oxford University Press, 2014.
- Divan Shyam and Armin Rosencranz: Environmental Law and Policy in India, Oxford University Press, 2002.
- P. B. Sahasranaman: Handbook of Environmental Laws, Oxford University Press, 2012.
- Nancy K. Kubasek and Gary S. Silverman: Environmental Law, Pearson, 1999.
- Paul Pojman and Louis Pojman: Environmental Ethics, Wadsworth Publishing, 2011.

- Joseph R. Des Jardins, Environmental Ethics: An Introduction to Environmental Philosophy, Wadsworth Publishing, 2005.

Title of the Course and Course Code	**Environmental Management Systems (EVS5402)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall basic concepts, principles in relation with environmental management. Identify the close relation between standard practices of management and development of standards.	
CO2	Explain important guidelines of Environmental management system standards.	
CO3	Identify environmental problems and apply appropriate knowledge, skills to selected case studies or real-life situations.	
CO4	Interpret and present EMS related data using different qualitative and quantitative techniques.	
CO5	Evaluate concept of circular economy and its role in sustainable development.	
CO6	Prepare reports based on different judgements and implementation in different parts of society. Collect and compile the surveys in relation with standard environmental management practices in different organizations.	

Units	Contents
Unit I	**Introduction to EMS** ● Organization's approach to the Environment ● Basics of Environmental Management ● The system of Environmental management ● Projecting EMS: planning, implementation, general requirements, control tasks ● Evaluation of Environmental performance ● Selection of Environmental indicators ● CSR and Environmental management **Sustainability and cleaner production** ● Principles of sustainable development ● Concept of clean production ● Characteristics of cleaner production ● Clean process and clean products ● Industrial ecology ● Use of alternative resources, clean energy and technology ● Evaluation of cleaner production

Unit II	**ISO 14001:2015** ● Introduction to ISO governance, structure and functions ● PDCA cycle ● ISO 14000 family of standards ● ISO 14001:2015: Guidelines for implementation of standard **Life cycle assessment** ● Concept of LCA ● Phases: Goal and Scope definition, Inventory analysis, Impact assessment, Interpretation ● Types: Cradle to grave, Cradle to gate, gate to gate, gate to grave ● Applications of LCA ● Benefits and value of LCA evaluation
Unit III	**Circular Economy** ● Concept of circular economy ● Principles ● Implementation of circular economy ● Waste to wealth solutions ● Circular economy and sustainable development ● Benefits: Environmental, economic and social ● Challenges **Eco-innovation** ● Concept of eco-innovation ● Preparation, Strategy, Business model, Implementation and review ● Eco-designs ● Environmental cost and benefits ● Environmental aspects and impact assessment in process ● Sustainable value chain
Unit IV	**Environmental regulations in India** ● The Water (Prevention and Control of Pollution) Act,1974 ● The Air (Prevention and Control of Pollution) Act,1981 ● The Environment (Protection) Act,1986 ● The Public Liability Insurance Act, 1991 ● National Green Tribunal Act,2010 **Environmental Ethics** ● Concept of Environmental Ethics ● Ethical theories applied to the Environment ● Ethics in Environment management ● Environmental ethics and pollution ● Challenges of World Environmental Ethics ● Environmental ethics and sustainability

Reference Books

- Sheldon, C., & Yoxon, M. (2012). Environmental management systems: a step-by-step guide to implementation and maintenance. Routledge.
- Tinsley, S., & Pillai, I. (2012). Environmental management systems: understanding organizational drivers and barriers. Taylor & Francis.

- Jackson, S. L. (1997). The ISO 14001 implementation guide: creating an integrated management system (Vol. 3). John Wiley & Sons.
- Welford, R. (2016). Corporate environmental management 1: Systems and strategies. Routledge.
- Ciambrone, D. F. (1997). Environmental life cycle analysis. CRC Press.
- Klöpffer, W., & Grahl, B. (2014). Life cycle assessment (LCA): a guide to best practice. John Wiley & Sons.
- Guinée, J. B., & Lindeijer, E. (Eds.). (2002). Handbook on life cycle assessment: operational guide to the ISO standards (Vol. 7). Springer Science & Business Media.
- Stahel, W. R. (2019). The circular economy: A user's guide. Routledge.
- Lacy, P., & Rutqvist, J. (2016). Waste to wealth: The circular economy advantage. Springer.
- Stahel, W. R. (2016). The circular economy. Nature, 531(7595), 435-438.
- Carrillo, J., Pablo del. Río González, & Totti. Könnölä. (2009). Eco-innovation: when sustainability and competitiveness shake hands. Palgrave Macmillan.

EVS 5403: Life cycle assessment (4 credits)

- It is a MOOC course please refer

http://ugcmoocs.inflibnet.ac.in/ugcmoocs/courses.php for course details.

Title of the Course and Course Code	**Restoration and Watershed Management (EVS5404)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define the different types of theories of Restoration and its application.	
CO2	Estimate the importance of interconnection between biotic, abiotic components of the ecosystem and relate it to environment protection and conservation issues through watershed management practices.	
CO3	Examine different examples of restoration practices as well as watershed management projects and perform different pilot studies related to it and recognize environmental issues associated with it.	
CO4	Analyse cost benefit analysis of restoration projects. Revise and evaluate restoration practices.	
CO5	Evaluate key challenges posed by developmental activities on natural processes and integrate restoration day techniques to solve different problems at local and regional level to attain a far-reaching goal of sustainability.	

CO6	Design experiments to understand different types of processes and concepts used in Environmental Biology.

Units	Contents
Unit I	**Part I- Restoration Ecology** ● History of Eco Restoration ● Definition and principles, ● Significances ● Guidelines ● Principles of Restoration ● Applications of Restoration Ecology **Part II-Restoration of urban ecosystem** ● Ponds, lakes, river banks, avenue trees, ● Biodiversity restoration through gardens, park, restoration of dumping grounds, ● Restoration of ecosystem on hills, ● Restoration of soil in urban areas, ● Ground water resource – replenishment, ● Sewage or wastewater – recycling for supporting ecosystems ● Case studies
Unit II	**Part I-Process of Restoration** ● Steps in the Process ● Understanding Limitations i) Biological Limitations ii) Physical Limitations iii) Chemical Limitations ● Overcoming Limitations (a few examples) i) Revegetation ii) Mulching iii) Equipment iv) Phytoremediation v) Collaborative Restoration **Part II-Restoration of other natural habitats/ecosystems** ● Mangroves ● Grasslands ● Wetlands and freshwater Ecosystems ● Degraded forest patches, ● Coastal ecosystems, ● Case Studies
Unit III	**Part I: Concept of watershed management** ● Definition, principle, objectives, ● Watershed morphology ● Characterization (with respect to size, elevation & slope, aspects & orientation, watershed shape, drainage network) **Part II: Watershed functions and survey** ● Collection, storage, dispersal, habitat, Attenuation response, flushing ● Engineering surveys involved in watershed development

Unit IV	**Part I: Water balance studies** ● Topographical survey, drainage line survey, contour survey, ● common instruments used for survey. ● Hydrological survey: Methodology for groundwater investigation, investigation of surface springs, ● vertical distribution of groundwater ● Case studies ● Water balance and hydrologic equation, inflow to the watershed, outflow from the watershed. **Part II: Water harvesting methods**: ● Traditional water harvesting structures such as nadis, Khadin, Rapats, Lakes, etc. contour bunding, graded bunds /field bunds, land leveling or terracing, farm ponds; ● Water harvesting in streams: Biological measures, check dam, gully plug, Gabion structure, Overflow weir, earthen dam, Underground bandhara. ● Soil and water conservation aspects: contour trenches, continuous contour benches, live hedges, infiltration pit, in situ conservation through appropriate cultivation practices ● Factors, problems associated with watershed management, ● Project monitoring and result indicators ● Repair and maintenance, etc. ● Success stories of watershed management/water harvesting projects in India and the world.

Reference Books

- Restoration of Nature by Prakash Gole
- Restoration Ecology the new frontier – edited by Jelte Van Andel and James Aronson – Wiley-Blackwell publication ISBN 9781444336368
- A source book for Ecological Restoration, Foundation for Ecological Security 2008
- Foundations of Restoration Ecology (The Science and Practice of Ecological Restoration Series), Donald A. Falk, Margaret Palmer,Joy Zedler, Richard J
- Watershed manual by BK Kakde (BAIF and LEAD India publication)
- Water Harvesting and Sustainable Supply in India by RN Athavale Centre for Environment Education ISBN: 8170337526
- Watershed Hydrology by Peter Black;Lewis Publishers: ISBN 1575040271
- Soil and water conservation engineering by R. Suresh – Standard Publishers and Distributors ISBN 8180140008

Title of the Course and Course Code	**Green Technologies (EVS5405)**	**Number of Credits : 04**
Course Outcomes (COs)		

On completion of the course, the students will be able to:	
CO1	Recall different types of green technologies by giving examples. Examine and interpret different methods of green techniques.
CO2	Illustrate the importance of reduce, reuse, recycle and classify different techniques associated to environment protection and conservation issues through green practices.
CO3	Examine different examples of green practices with respect to Green cities. Distinguish between practices of Green city policy and recognize Environmental, economical, social well-being associated with it.
CO4	Analyse cost benefit analysis and propose an Energy audit at the institutional level. Revise and evaluate green practices for Rural development.
CO5	Compare key challenges posed by green technologies and develop key solutions to the different environmental problems at local and regional levels.
CO6	Design experiments to understand different types of processes and concepts used in Green technologies. Evaluate the importance of green chemistry and energy efficient technologies and integrate them in planning and development for innovative solutions.

Units	Contents
Unit I	**Part I: Introduction to Green Technologies** ● Definition, Need of green technologies towards a sustainable future ● Green technologies in historical and contemporary perspectives ● Agenda of green development for future of the earth ● Sustainable consumption of resources ● Individual and community level participation ● Role of Industry, Government and Institutions ● 3 Rs of green technology: recycle, renew and reduce ● Emphasis on waste reduction instead of recycling ● Emphasis on research and innovations for green future ● Advances in science and technology for Environment friendly technologies in developed and developing world **Part II: Applications of Green Technologies** ● "Cradle to grave" approach in technology development ● Clean Production: Principles, importance, Historical evolution, Benefits, Promotion and Barriers ● Clean development mechanism, 3R, raw material substitution etc. ● Waste audit. Wealth from waste, case studies. ● Pollution Prevention and Cleaner Production, Awareness Plan, carbon credit, carbon sequestration, carbon trading

Unit II	**Part I: Green Infrastructure** ● Advances in green buildings and materials of high efficiency Construction and cost and benefit analysis ● Outlined examples of green buildings of the world ● LEED certification of buildings and future ● Eco-mark certification, scope and implementation **Part II: Green City Planning and Economy** **1.Concept of Green Cities** ● Technologies in waste management in cities and case studies ● Green cities of world and plans ● Role of informal sector in waste management and need for training ● Common public transport: ideas and plans ● Green belt development under various climatic conditions **2.Green Economy** ● UNEPs green economy initiative ● Inclusive economic growth of the society ● UN REDD+ initiative and cap and trade concept ● Green banking and success stories ● Green practices to conserve natural resources Importance and advances in ecological footprint
Unit III	**Part I: Green Biotechnology: Green solutions to reduce pollution** ● **Biopolymers and bioplastics:** Concept, types and applications ● **Biodegradable polymers:** production and applications ● Biodegradation of synthetic polymers ● Comparative studies of polymer degradation and environmental significance ● Bioindicators: Concept, classification and applications ● Biotechnology for environmental remediation ● Microbial remediation process: Principles of bioremediation, ● Concept of bio augmentation and bio stimulation. ● Factors affecting bioremediation process ● Types of Bioremediation: i) In situ ii) Ex situ ● Phytoremediation: Concept, types and applications **Part II: Green Biotechnology: Green technologies in rural environment** ● **Biopesticides:** Classification of Biopesticides: Bacterial, Fungal, viral ● Microbial bio pesticides: Production, stabilization, formulation, mode of action. ● Plant Product as biopesticides: production, mode of action, effectiveness in pest management e.g. Neem pesticides ● **Biofertilizers:** Role of Nitrogen fixing and phosphate solubilizing microbes in soil fertility, Classification, mode of application and production of biofertilizers ● **Composting and Vermicomposting:** Raw material, Process, Design aspects, influencing factors. ● Need of decentralised composting in rural and urban areas

	● **Green fuels:** Biofuels and Biodiesel ● Food safety and security using sustainable farming practices ● **Hydroponics:** Classification, production and application ● Agroforestry applications ● APCAEM and Green Technology Initiative ● **Impact of green technology in rural areas**: Socioeconomical, ecological and Environmental aspects. Case studies
Unit IV	**Part I: Green Chemistry** ● Introduction to green chemistry ● Principles and recognition of green criteria in chemistry ● Biodegradable and bio-accumulative products in environment ● Nanotechnology and its environmental applications ● Development of biodegradable and eco-friendly products ● Current research areas in green chemistry ● Waste reduction technologies in industries **Part II: Energy efficiency enhancement** **Green House Gas (GHG) emissions reduction** ● Carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, methane emissions reduction and/or reuse ● Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NOX, ● Fluidized Bed Combustion, Dioxins reduction and removal methods ● Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals ● Solvent recovery systems ● Low Volatile Organic Compound (VOC) paints and sealers

Reference Books

- Anastas, P.T. & Warner Green Chemistry: Theory & Practice. Oxford University Press
- Green Technologies: For a Better Future. Mc-Graw Hill Publications.
- Baker, S. 2006. Sustainable Development. Routledge Press.
- Hrubovcak, J., Vasavada, & Aldy, Green technologies for a more sustainable agriculture No. 33721. United States Department of Agriculture, Economic Research Service.
- Thangavel, P. & Sridevi, G. 2015. Environmental Sustainability: Role of Green Technologies. Springer Publications.
- Woolley, T. & Kimmins, S. Green Building Handbook (Volume 1 and 2). Spon Press.
- Pollution Prevention: Fundamentals and Practice Paul L Bishop (2000), McGraw Hill International.
- 'Pollution Prevention and Abatement Handbook – Towards Cleaner Production' by World Bank Group (1998), World Bank and UNEP, Washington D.C.

- 'Cleaner Production Audit' by Prasad Modak, C.Visvanathan and Mandar Parasnis (1995), Environmental System Reviews, No.38, Asian Institute of Technology, Bangkok
- Handbook of Organic Waste Conversion by Bewik M.W.M.
- Green Technology Choices: The Environmental and Resource Implications of Low-Carbon Technologies International Resource Panel Report.
- A Feasibility Study on the Application of Green Technology For Sustainable Agriculture Development: Assessing the policy impact in selected member countries of ESCAP-APCAEM.
  Environmental Biotechnology. M. H. Fulekar.
- Environmental Biotechnology. Alan Scragg, Oxford University Press.
- Environmental Biotechnology: Basic Concepts and Applications. Indu Shekhar Thakur, I. K. International Pvt. Ltd.
- 'Energy, The Solar Hydrogen Alternative' by Bokris J.O.

EVS 5406: Ecology and Society (4 credits)

- It is a MOOC course please refer http://ugcmoocs.inflibnet.ac.in/ugcmoocs/courses.php for course details

Title of the Course and Course Code	**Environmental Health, Toxicology and Safety (EVS5407)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recite the basic concepts in Environmental Health, Toxicology and Safety. List out and recall the scientific principles of these topics.	
CO2	Illustrate the role and responsibilities of an occupational health and safety practitioner. Clarify the policies and legislation on safety in industries and workplace environments. Describe concepts of Biological warfare and protective measures.	
CO3	Determine Toxicity testing methods and interpret the toxicity of Industrial toxicants and hazardous materials. Use epidemiological case studies for real time understanding of different aspects.	
CO4	Estimate Toxicity of different toxicants based on the concept of Toxicokinetics and Toxicodynamics. List and memorize various Parameters of toxicity testing.	
CO5	Evaluate the toxicity level of toxicants depending on the Interaction of toxicants in combination. Describe concept of Mutagens, Teratogens and Carcinogen and identify the source and effects of these materials.	
CO6	Design an experiment to study the exact dose of toxicity on the selected test organism aspects. Develop protocol for toxicity testing.	

Units	Contents
Unit I	**Part I: Safety, Health and Environment** ● Historical developments in EHS, Perspectives and concerns, ● Interrelationship and interactive approach on EHS, ● Development projects and related aspects of safety and health, ● Implementation of EHS practices in MNCs. ● International agreements on EHS, Case studies **Part II: Safety and Health Hazards** ● Identification of potential safety and health hazards in industry, Occupational Health Hazards ● Introduction to ISO 45001:2018 standard ● Scope, Safety policy of the organization, Leadership and worker participation, operation and performance evaluation ● Concept of Hazard and Risk ● Risk Reduction strategies for hazards ● Radiation and Industrial Hazards ● Electrical Hazards and Fire hazards ● Vibration and Noise associated hazards ● National and international policies and legislation on safety in industries
Unit II	**Part I: Health, Safety and Risk Management** ● Concept of Risk and risk identification, ● Risk assessment and risk communication ● Risk characterization and risk management ● Allocation and mitigation strategies ● Responsibilities and authority, ● Principles of accidents prevention ● Potential of health risks in industrial and development processes ● Local and national policies, public awareness and participation in ● prevention procedures. ● Industrial environmental conditions ● Emissions and noise abatement. ● Ecological risk assessment **Part II: Human Environment and Health Status in Urban and Rural India** • Water and sanitation situation in urban and rural context, • Historical perspective, • WHO and other bodies and their role in public health projects development • Policies and legal aspects on health and sanitation • Eradication programs of diseases and health management • Development impacts in urban and rural sectors, psychological impacts • Public awareness of sanitation and hygiene issues • Role of NGOs in environmental protection.

Unit III	**Part I: Toxic and hazardous waste management** ● Classification of toxic material ● Industrial toxicants and hazardous materials ● Product Stewardship ● Methods used for toxic and hazardous waste management ● Disaster management **Part II: Toxicology** ● Basic principles of toxicology: Concept of toxicants and xenobiotics ● Route of exposure ● Environmental Toxicology ● Classification of toxic materials. Industrial toxicants and hazardous materials ● Physiological and metabolic effects of toxicants, e.g.1) VOC and organic solvents, used in industry 2) Heavy metals such as Hg, Pb, AS, Cd etc.
Unit IV	**Part I: Evaluation of toxicity** • Concept of Toxicokinetics and Toxicodynamics • Bioconcentration, Bioaccumulation, Biomagnification and Bioavailability • Factors determining adverse effects of toxicants: Intrinsic toxicity, dose, exposure conditions, response of host • Parameters of toxicity testing: Acute toxicity, Chronic toxicity TU, ICp TER, NOEC, LOEC, LC 50, LD50, TLm • Toxicity testing methods: Using test animals • Non animal toxicity test methods: In vitro cell and tissue-based method, In silico method and integrated testing method • Toxicity test: Range finding, Screening, Definitive toxicity test • Interaction of toxicants in combination: Additive, synergistic and antagonistic effects • Alternatives to animal tests • Mutagens, Teratogens and Carcinogen: Definition, sources, effects • Prevention, treatment and control **Part II: Water and airborne Diseases** • Potential and widespread effects of Water and airborne bacteria and viruses: Endemic, Epidemic and pandemic diseases • Waterborne bacterial and viral Diseases: causative agent, Spread of disease, symptoms, preventive and curative measures. Case Studies • Waterborne bacterial and viral Diseases: causative agent, Spread of disease symptoms preventive and curative measures. Case Studies • Human immune-system and its vulnerability to these bacteria and viruses, Concept of Hurd immunity • Biological warfare and protective measures • Case studies: Swine flu, Cholera, Covid -19 • Safeguarding water sources and ambient air quality

Reference Books

- Principles of Environmental Toxicology,I.C.Shaw and J. Chadwick; Taylor& Francis Ltd.
- Basic Environmental Health (2001): AnnaleeYassi, TordKjellstom, Theo de Kok, Tee Guidotti. Oxford University Press.
- Environmental Health (2005): Dade W. Moeller, Harvard University Press. USA
- Handbook of Environmental Health and Safety: Principle and practices. Herman Koren and Michael S. Bisesi. Lewis Publishers.
- Essentials of Environmental Health (2006): Robert Friis. Jones & Bartlett Publishers
- Walker, C.H., Hopkin, S.P., Sibly, R.M., and Peakall, D.B. (2001):
- Principles of Ecotoxicology. 2ndEd. Taylor & Francis, London.
- Environmental Biology and Toxicology (2014): P. D. Sharma, Rastogi Publications.
- Environmental Pollution and Toxicology: M.K. Rao. Manglam Publishers & Distributors.
- Environmental Pollution: Health and Toxicology: S.V.S. Rana. Narosa Publishing House.
- Toxicology (1999): A.Sood, Sarup and sons New Delhi.
- Environmental Epidemiology: Anisa Basheer, Rawat Publication Jaipur, New Delhi
- Industrial Hygiene & Chemical Safety: M.H.Fulekar, I. K.International Publishing House,
- Principles of Fire Safety Engineering: Understanding Fire and Fire Protection (2014): Akhil Kumar Das. Prentice Hall India Learning Private Limited.
- Industrial Safety and Environment (2013): AnupamaPrashar. S.K. Kataria& Sons.
- Occupational Safety Management and Engineering (2001): Willie Hammer, Prentice Hall.
- Fundamentals of Occupational Safety and Health, Mark A. Friend, James P. Kohn
- Industrial Safety, Health Environment and Security, Basudev Panda.Laxmi Publications
- Occupational Hygiene (1995): Blackwell Science,Harrington, J.M. & K. Gardiner. Oxford.
- Industrial Safety, Health and Environment Management Systems: R..Jain and S. Rao.
- Industrial Safety -National Safety Council of India. Reports and Survey Papers. The Factories Act with amendments. Govt. of India Publications DGFASLI, Mumbai.
- Risk Characterization handbook, US-EPA,2000
- Links: https://www.epa.gov/risk
  https://www.epa.gov/risk/conducting-human-health-risk-assessment#tab

Title of the Course and Course Code	**Energy Resources and Technologies (EVS5408)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Recall concepts of renewable and non-renewable energy resources, its importance and limitations. Outline methods of harnessing renewable energy and their global availability.	
CO2	Describe the basic principles and technologies to harness various energy resources. Discuss the merits and demerits of energy generation technologies.	
CO3	Develop energy generation process using lab scale models of biogas plant, wind mills, solar devices.	
CO4	Analyze advanced technologies available for energy harnessing by using different methods.	
CO5	Evaluate appropriate energy harvesting techniques based on its availability, importance and technological and ecological and economical aspects, Judge the future potential of renewable energy resources.	
CO6	Design a method to study biogas production. Develop protocol to work on biomass conversion process.	

Units	Contents
Units I	**Part I: Energy and Environment** ● Energy consumption as a measure of prosperity ● Global energy use pattern and impacts on the environment ● Energy usage: Heat, power, transportation, light ● Sources of energy and their classification ● Energy forms and transformation. ● Sun as source of energy and solar spectrum, ● Solar radiations: Absorption, reflection, scattering and diffusion in the atmosphere ● Renewable energy integration and decentralized generation systems. ● Electricity production and distribution: Electrical grid, smart grid, energy storage **Part II: Solar Energy** ● Harnessing of solar energy, ● Photovoltaics, Solar Home Systems ● Solar energy collectors and concentrators, ● Solar thermal heating: Solar water heater and CSP ● Solar electricity generation 1.Direct: with PV modules 2, Indirect: with Concentrated Solar Power (CSP)

	● Applications of solar energy: Solar heaters, dryers, and cookers, solar thermal cooling ● Solar energy storage methods, Solar Kiosk
Units II	**Part I: Hydro electricity** ● Principle, Generating methods, ● Sizes, types and capacities of hydroelectric facilities. ● Classification of hydropower plants 1.Based on size: Large, medium, mini, micro, pico 2.Based on facility: Run-of river, Storage / Reservoir, Pumped storage ● Peaking with hydropower. ● Hydropower Potential: World and India. ● Hazard related to hydropower generation and distribution, ● Hydropower, Society and the Environment **Part II: Geothermal and Hydrothermal Energy** ● Types of geothermal resources: hydrothermal geopressured, hot dry rock, magma ● Natural geothermal fields, Exploration and drilling ● High temperature and low temperature aquifers, ● power generation from Geothermal energy: Dry Steam Plants, Flashed Steam Plants, Binary-Cycle Plants, supercritical cycle ● Prospects of geothermal energy: World and India ● Hydrothermal energy: Vapour and liquid system; ● Operation and environmental problems. ● Applications of Geothermal energy
Units III	**Part I: Fossil Fuels** ● Concept of fossil fuels. ● Classification and composition ● Formation, reserves, and consumption ● Exploration, hydraulic fracturing, drilling mining, processing, and transportation ● Environmental problems associated with fossil fuel ● Case studies of thermal power plants **Part II: Bio-energy** ● Biomass composition and types ● Biomass Conversion processes: direct combustion, thermo chemical, biochemical processes ● Production of Solid, liquid and gaseous fuels from biomass: pyrolysis, charcoal production, ethanol, methanol, esters and hydrogen ● Electricity generation from biomass ● Biodiesel Production ● Energy plantation ● Biogas: anaerobic digestion production and uses,

	● Energy from Solid Wastes: Sources, types, energy production. ● Bio-energy and Waste to Energy Conversion Systems ● Energy Conservation and Management
Unit IV	**Part I: Nuclear energy** ● Nuclear energy generation: Nuclear fission and fusion ● Nuclear fuel cycle: Nuclear fuel production and processing Mining and processing of Uranium, concentration, refining, Enrichment and fuel fabrication ● Nuclear waste generation sources and classification ● Treatment and disposal of radioactive waste. ● Environmental implications of Nuclear energy. **Part II: Wind energy** ● Principle of Harnessing of wind energy ● Factors affecting wind energy generation ● Power generation by wind mills, concentrators, ● Wind characteristics and siting, ● Environmental considerations ● Wind energy potential in India. ● Numerical Methods and Computational Techniques, ● Wind Energy. ● Conversion Systems

Reference Books

- Conventional and Non-conventional Energy sources G. D Rai.
- Renewable Energy Resources: Basic Principles and Applications Tiwari, G.N., Narosa Publishing House.
- Renewable Energy Programs in India: some recent developments, Sinha P.C., Natural Resource Forum, 18(3), 1994.
- Renewable Energy Environment and Development, Maheswar Dayal Konark Publishers pvt. Ltd.
- Alternative Energy: S. Vandana; APH Publishing Corporation
- Nuclear Energy – Principles, practice and prospects: S. K. Agarwal; APH Publishing Corporation
- Bio-Energy Resources: Chaturvedi; Concept Pub.
- Geography and Energy – Commercial energy systems and national policies: J. D. Chapma
- Reclamation, managing water in the west: Hydroelectric power. us department of interior Bureau of Reclamation Power Resources office,2005
- https://energypedia.info/wiki/Main_Page
- https://www.studentenergy.org/topics/

EVS 5409: Waste to Energy conversion (4 credits)

- For MOOC course please refer http://ugcmoocs.inflibnet.ac.in/ugcmoocs/courses.php for course details.

Title of the Course and Course Code	**Practical 6 (EVS5410)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	State Environmental management system tools and select suitable tools like LCA, Environmental Audit for natural resource conservation.	
CO2	Discuss the challenges associated with environmental governance in India and overall challenges in different societies. Compare various issues associated with implementation of environmental management at national and international level.	
CO3	Outline the features on toposheets. Analyze the watershed for length, area and perimeter, measure the slope of watershed. Construct the longitudinal profile of river.	
CO4	Compare processes and behavior of green techniques with different species and varieties. Collect information and studies with proper understanding. Specify the role towards function.	
CO5	Evaluate toxicity level of toxicants from different sources on the selected test organisms. Relate the response of test organisms towards the dose of toxicant of industrial waste.	
CO6	Design simple and innovative energy making instruments for rural areas, questionnaire for inspection of solar home systems.	

Practicals based on EVS5401: Environmental Law Ethics Policies

1. Baseline survey on provisions under selected environmental laws
2. Learning and understanding law specific case study
3. Study of regulations under specific laws
4. Study of major judgement given by courts on selected law
5. Study of case studies related to fundamental duty and rights
6. Preparation of drafts report on various Environment related policies in India
7. Learning: How to file case under Environmental laws
8. Study and understanding of consent forms
9. Study of challenges associated with Environmental governance
10. Study of issues and challenges associated with Environmental ethics

Practicals based on EVS5402: Environmental Management Systems

1. Study of industrial process for Environmental management
2. Identification of Environmental aspects of a process
3. Identification of Environmental impacts and its assessment
4. Writing Environmental policy for an organization
5. Understanding environmental objectives from policy statement
6. Study of PDCA cycle
7. Case studies based on circular economy
8. Study of success stories of Eco-innovation
9. Study of challenges associated with Environmental governance
10. Study of issues and challenges associated with Environmental ethics

Practicals based on EVS 5404: Restoration and Watershed Management

1. Visit to Restoration site and survey of techniques used in Restoration
2. Study of phytoremediation techniques.
3. Preparing/Monitoring a plan of restoration.
4. Delineation of watersheds using toposheets and estimation of perimeter, area and slope.
5. Surveying and preparation of watershed map.
6. Quantitative analysis of watershed characteristics and parameters.
7. Watershed investigations for planning and development: identifying specific watershed interventions required.
8. Visit to watershed development project areas.

Practical based on EVS 5405: Green Technologies

1. Monitoring a plan for Green city
2. Study of various indices used for Green City**.**
3. Conducting green audit of a building/ institution.
4. Market survey for organic products/green product/eco-friendly products.
5. Development and study of hydroponic system.
6. Study the plant growth characteristics using hydroponic system.
7. Survey and analysis of data for sustainable agriculture practices/organic farming in rural area.
8. Isolation of phosphate solubilizing bacteria/fungi.
9. Estimation of phosphate solubilisation efficiency of bacteria/ fungi.
10. Wastewater treatment by phytoremediation technique.

Practical based on EVS 5407: Environmental Health, Toxicology and Safety

1. Conducting ecological risk assessment.
2. Conducting Human risk assessment.
3. Effect of toxicant on chick embryo

4. Effect of toxicant on seed germination
5. Fish bioassay for toxicity testing
6. Probit Analysis for toxicity studies
7. Finding the LC_{50} / LD_{50} dose of toxicant/ pollutant
8. Survey for identification of effect of pollution on human health
9. Monitoring effect of pollution on aquatic ecosystem
10. Monitoring effect of pollution on plants
11. Safety audit in industries.
12. Epidemiological studies: Ecological Study/Cross sectional study/ Case control study

Practicals based on EVS5408: Energy Resource and Technologies

1. Computing or Measurement of hydropower capacity of a selected site.
2. Monitoring of sustainability of Solar Home Systems based on questionnaire and field survey.
3. Development/ designing and application of simple sustainable and innovative energy devices for rural and undeveloped sectors. e. g solar bottle bulb, solar lamps, biofuel-based devices etc.

Note: Any other equivalent practical

Title of the Course and Course Code	**Dissertation (EVS5411)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define the need for selection of project work in relation to the current environmental topics as per social aspects. Recall techniques, basic terms related to research topics and research work.	
CO2	Classify the basic concepts in research to implement the dissertation. Associate the objectives as per topic of research in the environmental field. Compare different research implementation ways as per other research workers.	
CO3	Apply the objectives of the work to solve the issues of the society. Calculate the impacts on the environment by using well known methods.	
CO4	Analyse research-oriented approach to solve environmental issues and test it with the help of innovating solutions.	
CO5	Compare techniques used in restoration studies. Outline the outcomes of restoration projects.	
CO6	Design an experimental setup and develop lab scale model to generate data and interpret it for solving environmental problems. Develop protocol to	

	work on the selected dissertation topic for systematic research work.

- Students are expected to undertake the subject related research projects for learning skills related to research methodology and work reports need to be submitted.
- Student need to select Lab or field based project.
- Weekly reporting of the progress of work should be done to the Faculty/ Mentor of the department.