M. Sc. Environmental Sciences

Syllabus

UNIVERSITY DEPARTMENT

Program Code: ENVA

2020 – 2021 onwards

BHARATHIAR UNIVERSITY

(A State University, Accredited with "A" Grade by NAAC,
Ranked 13th among Indian Universities by MHRD-NIRF,
World Ranking : Times - 801-1000, Shanghai - 901-1000, URAP - 982)

Coimbatore - 641 046, Tamil Nadu, India

Program Educational Objectives (PEOs)	
The **M. Sc. Environmental Sciences** program describe accomplishments that graduates are expected to attain within five to seven years after graduation	
PEO1	The students could get employment opportunities in Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB), Research Institutions, Colleges, Universities and Non-governmental organizations.
PEO2	After successful completion of the course, the students could get job opportunities in urban and rural environmental mitigation and awareness including social forestry programs, biofertilizer and biopesticide industries, waste management and organic farming divisions funded by National, International and Regional agencies.
PEO3	The students could get employment perspectives in R & D laboratories of waste water treatment plants, metal, chemical and textile effluent treatment plants, municipal solid waste management units and waste management in biomedical industries and hospitals.
PEO4	The students could find employment opportunities in agro industries, forest departments, water harvesting and watershed management sectors, bioresource utilization and biodiversity conservation organizations, food and feed Industries, environment friendly and integrated livestock management sectors.
PEO5	Students also having the immense opportunities to pursue higher studies in various research fields such as environmental pollution, environmental chemistry, waste management and bioremediation, environmental microbiology, waste water treatment, recycle, reuse and management, sustainable environmental food security, bioresource utilization and biodiversity conservation, functional and ecosystem ecology, environmental toxicology, xero agrowaste ecosystem, non-biodegradable synthetic chemicals and polymers in environment, occupational health and industrial safety, environment analytical techniques, environmental impact assessment, remote sensing and geographical information system, environmental biotechnology, carbon sequestration, natural disaster management and mitigation, climate change, marine pollution and resources utilization, restoration of different ecosystems, renewable and green energy and environmental law, policies and auditing.

Program Specific Outcomes (PSOs)	
After the successful completion of M.Sc. Environmental Sciences program, the students are expected to	
PSO1	Get practical knowledge about various physico-chemical parameters, mechanisms of chemical reactions and removal/reduction of air, soil and water pollutants from the environment through different analytical techniques.
PSO2	Understand the importance and conservation perspectives of natural resources, impact of climate changes in environment, biological diversity and sustainable environmental management with restoration of functional ecosystem and ecology including environmental food security.
PSO3	Understand about the environmental toxicology, health issues and industrial safety perspectives in regional, national and global levels, environmental law, policies and importance and role of environmental impact assessment.
PSO4	Understand the basic and application of remote sensing and geographical information system in the studies and characterization of natural resources, geospatial, species distribution and mapping attributes in different environment and ecosystems.
PSO5	Understand about the wealth from waste, recycle, reuse, xero waste discharge, xero waste agroecosystem and environment through production of biocomposts and regenerating of useful byproducts from the waste and waste minimization aspects
PSO6	Understand the importance and role of microbial consortium along with biotechnological tools as nature based solution for effective implementation of bioremediation, waste management, green energy and sustainable environment.

Program Outcomes (POs)	
On successful completion of the M. Sc. Environmental Sciences program	
PO1	Students would acquire knowledge on the fundamental concepts of chemistry, atoms, molecules, bonding phenomenon, chemical reactivity and product outlet related to environmental chemistry. Students would also have more familiar with the classification of various pollutants such as air/water/soil and physical, chemical and biological control methods of above said pollutants in the environment.
PO2	Students could acquire knowledge with reference to designing of methods, way of data collection, analysis of data, interpretation of results to solve the environmental problems through the assessment of qualitative and quantitative characters, by using artificial intelligence, big data, data analysis and internet things.
PO3	Students will get skill development on qualitative and quantitative analysis of environmental samples by using different analytical instruments techniques. Students also understand the work place hazards, mitigation by employing safety devices and also aware of environmental safety standards, certification, safety auditing and management perspectives.
PO4	Students gain knowledge about the importance of natural resources, distribution, utilization, conservation strategies, green energy sources and sustainable management perspectives. Further, students will also be able to understand the importance of environmental impact assessment, public participation in environmental impact assessment and EIA report preparation before implementing potential environmental projects in National, International, Regional and Local levels.
PO5	The students could understand the different type of natural disasters, causes, and impact on natural and man-made environments. Further, students gained knowledge will enable to become volunteers themselves in disaster management program for helping the affected community. Nonetheless, students will also acquire knowledge regarding the importance of preparedness in vulnerable areas. The students could understand the uses of sensors to collect spatial geographic data, generate geographical information by processing the digital data and application of RS, GIS and GPS tools to assess various environmental components such as distribution of forest area including vegetation and wild animals, land and water resource area distribution and mapping etc.
PO6	Students will be able to acquired technical knowledge about the fundamentals of industrial effluent treatments, water and sewage wastewater treatments, environmental protection with pollutants free, zero waste discharge and operating of pollution control devices technology. Students will be able to understand the key features of environmental laws, acts and legal obligations, applying of green auditing tools and techniques, conducting of onsite assessment and preparation of audit reports before implementing the potential public environmental projects.
PO7	Students will be able to gain technical skills and knowledge of the various environmental toxicants, toxicants in food, drugs, weedicides, heavy metals, pesticides, organic and inorganic chemical molecules, exposure routes of toxicants, toxicological test methods and animal ethics to be followed in toxicological testing studies.
PO8	The students will be able to acquire and understand the management strategies of solid and liquid wastes from municipal and industrial sources, remediation measures of recycling, reuse and recovery from wastes, principles and mechanistic role of machines in the degradation of various pollutants. Students would have gained knowledge about

	the strategic phenomenon of environmental planning, life cycle assessment, material analysis, environmental impact assessment, risk assessment, environmental auditing, issues in various industrial sectors in cooperation with federal, state and local governing body and official work for mitigation strategies in issues pertaining to the environmental protection. Students will also be able to acquired knowledge about the role and importance of environmental education among the school children. Through obtaining the environmental awareness knowledge, students will be able to understand nature based mitigation efforts to save the sustainable environment and ecosystem for feature.
PO9	Students will be able to acquired practical knowledge about the need of agroforestry and biophysical process, role of agroforestry system in soil fertility and nutrient cycling, integrated livestock management, tree crops-soil interaction, opportunities of employment and cash income through agroforestry. The students will be able to understand the importance and application of biofertilizers and biopesticides in soil fertility improvement and crop productivity and exploitation of their potential for sustainable agriculture. Students could also understand the integrated nutrient management and integrated pest management approaches through indigenous knowledge based techniques.
PO10	Students will be able to understand and acquire knowledge about the recent approaches of industrial systems including sources and energy utilization, product generation and waste minimization to achieve zero pollution status. Further students will also be able to acquire practical knowledge on air quality monitoring attributes in urban and industrial environment, mitigation measures in industry, current national standards and guidelines for air quality assessment and maintaining the clean air environment.

BHARATHIAR UNIVERSITY: COIMBATORE 641 046

M. Sc. Environmental Sciences Curriculum (University Department)

(For the students admitted during the academic year 2020 – 21 onwards)

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
FIRST SEMESTER							
20ENVA13A	Environmental Chemistry	4	4		25	75	100
20ENVA13B	Environmental Pollution	4	4		25	75	100
20ENVA13C	Data Analytics and Research Methods	4	4		25	75	100
20ENVA13D	Instrumental Methods of Analysis	4	4		25	75	100
20ENVA1EA	Ecology (or) Natural Resource Management	4	4		25	75	100
20ENVGS18	Ecotourism	2	2		12	28	50
20ENVA13P1	Practical -I	4		6	25	75	100
Total		**26**	**22**	**6**	**162**	**478**	**650**
SECOND SEMESTER							
20ENVA23A	Environmental Impact Assessment and Green Auditing	4	4		25	75	100
20ENVA23B	Environmental Microbiology and Biotechnology	4	4		25	75	100
20ENVA23C	Biodiversity and Conservation	4	4		25	75	100
20ENVA23D	Introduction to Industry 4.0	4	4		25	75	100
20ENVA2EB	Natural Hazards and Disaster Management (or) Environmental Geosciences	4	4		25	75	100
20ENVGS53	Natural Disaster Management	2	2		12	28	50
20ENVA23P1	Practical - II	4		6	25	75	100
Total		**26**	**22**	**6**	**172**	**478**	**650**
THIRD SEMESTER							
20ENVA33A	Remote Sensing and GIS	4	4		25	75	100
20ENVA33B	Environmental Engineering	4	4		25	75	100

20ENVA33C	Environmental Law, Policy and Auditing	4	4		25	75	100
20ENVA33D	Environmental Toxicology	4	4		25	75	100
20ENVA33E	Waste Management and Bioremediation	4	4		25	75	100
20ENVA3EC	Environmental Health and Industrial Safety (or) Environmental Management and Sustainable Development	4	4		25	75	100
20ENVGS03	Environmental Education and Awareness	2	2		12	38	50
20ENVA33P1	Practical -III	4		6	25	75	100
Total		**30**	**26**	**6**	**187**	**563**	**750**
FOURTH SEMESTER							
	Project Work and viva-voce Examination	6					150
	Industrial Visit and Summer Project	2					50
Total		**8**					**200**
Grand Total		**90**	**70**	**18**	**421**	**1519**	**2250**

CO-SCHOLASTIC COURSES							
ONLINE COURSES							
	Swayam, MOOC Course etc.,	2	-	-	-	-	-
VALUE ADDED COURSES							
	Value Added Course - I	2	30	-	50	-	50
	Value Added Course - II	2	30	-	50	-	50
CERTIFICATE COURSES							
	Certificate Course - I	4	30-40	-	100	-	100
	Certificate Course - II	4	30-40	-	100	-	100
The scholastic courses are only counted for the final grading and ranking. However for the award of the degree, the completion of co-scholastic courses is also mandatory.							

First
Semester

Course code	20ENVA13A	ENVIRONMENTAL CHEMISTRY	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Basic knowledge on various chemical process	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Impart knowledge on the fundamentals of chemical process
2. Understand the environmental problems
3. Study for solving various environmental issues

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Have a basic understanding on the fundamental concepts of chemistry - atoms, bonding a chemical molecules	K2
2	Understand the sources, classification and formation of chemical pollutants and their impact on environment	K2
3	Have detailed knowledge on various physico-chemical parameters, chemical reactions and removal/reduction of air, soil and water pollutants from the environment	K2
4	Have the skill to design a field research on environmental problems for sustainable maintenance of the functional ecosystem	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Concept and Scope of Environmental Chemistry	14 – hours

Atomic structure, their properties, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality, quantitative volumetric analysis. redox reactions, concepts of pH and pE, electrochemistry, Nernst equation, electrochemical cells

Unit:2	Stoichiometry and Types of Chemical Reactions	14 – hours

Acids, bases and salts, solubility products; solutes and solvents; solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, Radio nuclides. Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups. Gasoline, antiknock compounds, lubricants and greases, biogas, PAH, PCBs, phenols, chlorofluorocarbons, pesticides, chemical fertilizers.

Unit:3	Atmospheric and Photochemical Reactions	14 – hours

Classification of elements, chemical speciation, Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Laws of mass action and Applications, Le-Chatlier Braun principle. Principles of photochemistry, fluorescence, phosphorescence, photochemical and photosensitized reactions. Thermochemical and photochemical

reactions in the atmosphere, Oxygen and ozone chemistry, Chemistry of air pollutants, greenhouse gases; Photochemical Smog, free radicals and ozone layer depletion, role of CFCs in ozone depletion. aerosols; chemistry of acid rain, reactions of NO_2 and SO_2.

Unit:4	**Thermodynamics and Chemical Potential**	**14 – hours**

First law of thermodynamics, enthalphy, adiabatic transformations, second law of thermodynamics, Carnot's cycle, entropy, Gibb's free energy, chemical potential, phase equilibria, Gibb's Donnan equilibrium, third law of thermodynamics, enzymes catalysis, Michaelis/ Menten equation, exothermic and endothermic reactions, spontaneous and nonspontaneous reactions.

Unit:5	**Water, Soil, Surface, Interface and Polymer Chemistry**	**14 – hours**

Chemistry of water, alkalinity and acidity of water, hardness of water, concept of DO, BOD, and COD. Heavy metals, metal solubility, complexation and chelation. Wastewater treatment: Primary, Secondary and tertiary treatments. Advanced water treatment techniques, redox potential. Organic compounds -hydrocarbons, functional groups, nucleophiles and electrophiles. Surface and interface chemistry - Adsorption, absorption, catalysis, colloids, surfactants, examples, types of adsorption, desorption. Synthetic Polymers: biological decomposition, polymer decay, ecological consideration. Inorganic and organic components of soil, anion and cation exchange reactions in soil, nitrogen pathways and NPK in soils.

Unit:6	**Contemporary Issues**	**2 – hours**

Expert lectures, online seminars – webinars

	Total Lecture hours	**72 – hours**

Text Book(s)

1. Fundamental Concepts of Environmental Chemistry, Sodhi, G.S. (2009),Alpha Science International Ltd.
2. Environmental Chemistry, (5th Ed.), De, A. K. (2002), New Age International (P) Ltd.
3. Fundamentals of Environmental Chemistry, 3rd Edition, Manahan, E. S. (2011). CRC Press.
   Photochemistry &Spectroscopy, Simons, J. P. (1971), Wiley Interscience.
4. Fundamentals of Photochemistry, Rohatgi-Mukherjee, K. K. (2006), New Age International
5. (P) Ltd.
   Elements of Environmental Chemistry, Jadhav, H. V. (1992), Himalya Publication House.
6. Environmental Chemistry, Sharma, B. K. and H. Kaur, H. (1994), Goel Publishing House
7. Environmental Chemistry, Moore, J. W. and Moore, E. A. (1976), Academic Press
8. Inc.

Reference Books

1. Environmental Chemistry A global perspective, (4th Ed.), Van Loon, G. W. and Duffy, S. J. (2017), Oxford University Press.
2. Chemistry of Atmospheres: An Introduction to the Chemistry of the Atmospheres of Earth, the Planets, and their Satellites (3rd Ed.), Wayne, R. P., (2000), Oxford University Press.
3. Basic Concepts of Environmental Chemistry (2nd edition), Connell, D.W. (2005), CRC Press.
4. Textbook of Environmental Chemistry, Pani, B. (2007), IK International Publishing House.
5. Elements of Environmental Chemistry (2nd edition), Hites, R.A. (2012), Wiley & Sons.

6	Standard Methods for the Examination of Water and Waste Water, (23rd Ed.), APHA, (2005), Washington, D.C.
7	Fundamentals of Soil Science, (8th Ed.), Futh, H. D. (2016), Wiley India.
8	Lehninger Principles of Biochemistry, (7th Ed.), Nelson, D. L. and Cox, M.M. (2017).W.H. Freeman & Co.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ce57/
2	https://www.openlearning.com/courses/introduction-to-environmental-chemistry/
3	https://freevideolectures.com/course/2908/green-chemistry-an-interdisciplinary-approach-to-sustainability
Course Designed By: Dr. P. Siddhuraju, Dr. R. Rajkumar	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	S	M	S	S	S	M	S
CO2	S	M	S	S	M	S	M	S	S	S
CO3	S	S	M	M	S	S	S	M	M	M
CO4	M	S	S	M	S	S	S	M	S	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA13B	ENVIRONMENTAL POLLUTION	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Knowledge in basic chemistry and biology	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Educate the students on source, classification, impact and control measures of air, water and soil pollution
2. Make students aware of the industrial disasters and their consequences on environment and human and animal health.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the sources and classification of Air pollutants and their impact on environment	K2
2	Know the properties of water, classification and the effects of water pollutants	K2
3	Understand the sources, sinks and broad classification, movement and sorption soil pollutants	K2
4	Gain detailed knowledge about physico-chemical and biological control methods of various air/soil/water pollutants.	K3
5	Gain more information about the causes, consequences and control measures of industrial disasters	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Atmospheric Pollution	14 - hours

Structure of the atmosphere, Sources and Classification of Air Pollutants. Transport and Diffusion of Pollutants. Plume behavior and stack dispersion, Reactions of hydroxyl radical withO_2, N_2, CO_2 and Oxides of Nitrogen, Sulphur and Carbon. Sinks of Air pollutants – Acid rain: Ozone depletion – Montreal protocol; Global warming – Kyoto protocol; Gaseous pollution control measures; photo chemical smog; Automobile pollution in India; Particulate matter pollution – PM 10 and PM 2.5 – Cleaner technologies – online monitoring of pollution.

Unit:2	Water Pollution	14 - hours

Properties of water – water quality, DO, BOD, COD, acidity, alkalinity, salinity, hardness; drinking water quality standards; Water pollution; Classification of water pollutants, Groundwater pollution, Sources and sinks, Eutrophication. Purification of water by adsorption, flocculation, ion exchange and reverse osmosis methods. Alternatives of end of pipe treatments, online monitoring of industrial effluents – Marine pollution- sources & control.

Unit:3	Soil Pollution	14 - hours

Sources, sinks and broad classification, movement and sorption mechanisms of organic and inorganic contaminants and their impacts on physico-chemical and biological properties of soil and plants, Sediment Pollution – Black carbon – Soil pollution control measures – Physico-chemical and Biological methods.

Unit:4	**Hazardous Solid Wastes**	**14 - hours**
Hospital Wastes, Radioactive Wastes - Sources, Transport, Disposal. Municipal solid wastes - hazards, disposal and energy production- Case studies; Light pollution and control measures; and Thermal pollution and control measures. Noise pollution – Sensing, Measurement, Abatement measures.		
Unit:5	**Industrial Disasters and Pollution**	**14 - hours**
Remedial measures – Case studies-Chemical Industries –Pesticide Industries, Bhopal Disaster, Chernobyl accident, Love canal Disaster, Oil Disasters –Exxon, British Petroleum- Gulf of Mexico; e-wastes, Impact and Remedial Measures.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Chemistry for Environmental Engineering and Science, Sawyer, C.N., Mc Carty P.L., and Parkin, G. F. (2003), Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2	A text book of environmental chemistry and pollution control, Dara, S. S.(1998), S. Chand & Company Ltd, New Delhi
3	Environmental Engineering, Howard S Peavy, H. S. (2003), Tata McGraw Hill Publishing Company Ltd., New Delhi
4	Environmental Chemistry, De, A. K. (2001), New Age International Publishers, New Delhi.
Reference Books	
1	Environmental Chemistry, Manahan, S. E. (2000), CRC Press, USA.
2	An Introduction to Soils and Plant Growth, 5th Edition, Donalue, R. I., Miller, R. W. and Shiekluna, J. C. (1987), Prentice Hall of India.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.who.int/ceh/capacity/Outdoor_air_pollution.pdf
2	https://ocw.mit.edu/courses/chemical-engineering/10-571j-atmospheric-physics-and-chemistry-spring-2006/
3	https://www.unenvironment.org/beatpollution/forms-pollution

Course Designed By: **Dr. M. Rajkumar**

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	S	S	M	S
CO2	S	S	S	M	S	S	S	S	M	S
CO3	S	S	S	M	S	S	S	S	S	S
CO4	S	S	S	S	S	S	S	S	M	S
CO5	M	M	S	M	S	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Course code	20ENVA13C	DATA ANALYTICS AND RESEARCH METHODS	L	T	P	C
Core/elective/Supportive		Core	4	0	2	4
Pre-requisite		Basic knowledge on computer and statistics	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Impart understanding on the concepts of data analytics
2. Impart understanding on the concepts of statistics
3. Improve the computing knowledge of statistical methods related to environment

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the basic concepts of statistics	K2
2	Extract information and draw scientific inference from ecology and environment related data	K3
3	Analyze, model and quantify in environmental models	K4
4	Understand the basic concepts of Big data analytics	K2
5	Design and execute a well-planned field research	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Fundamentals of Statistics	14 - hours

Basic concept, Collection of Data – Classification and Tabulation – Diagrammatic Representation – Measures of Central Tendencies and Dispersion – Probability – Moments, Skewness and Kurtosis – Normal, Poisson and Binomial Distributions. Sampling Methods: Probability sampling, random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgement sampling, quota sampling.

Unit:2	Tests of Significance	14 - hours

Mass and alternative hypothesis – error level of significance – Equal and Unequal Sampling - t, z, x2 test, Analysis of variance – One way ANOVA – Two way ANOVA – Regression and correlation - simple and multiple. Introduction to environmental system analysis, Approaches to development of models, models of population growth and interaction-various models.

Unit:3	Computer Applications	14 - hours

Data Analysis using packages (SPSS): Editing, Data Tabulation, Descriptive statistics, Multivariate Analysis – Correlation – Regression –Cluster analysis – Factor Analysis -PCA, Graph Plotting, Computational databases and environmental management.

Unit:4	Scientific Documentation	14 - hours

Methods of literature collection, design, planning and execution of investigation, Preparation of scientific documents, general articles, research papers, review articles, editing of research papers, methods of citation, collection of literatures, including web based methods, bibliography and thesis writing. Presentation techniques, effective communication skill.

Unit:5	**Data Science**	**14 - hours**
A Discipline – Data Science vs Statistics. Data Science Components – Data Engineering - Data analytics – Methods and Algorithm – Data Visualization. Big data - Characteristics of Big Data 6Vs - Types and Classifications- Sources -Technology Process – Big Data Exploration –Data Augmentation. Big Data Platforms –HADOOP-SPARK- NoSQL Databases. Big data analytics – R software environment. Big Data Applications in Industry- Healthcare- Environmental Sciences.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Statistical Methods 43rd Edition. Gupta, S. P. Sultan Chand & Sons Publications, New Delhi
2	P. Kaliraj, T. Devi, Higher Education for Industry 4.0 and Transformation to Education 5.0, 2020
3	Fundamentals of Bio-Statistics, Khan, I.A. and Kanum, A. (1994), Ukaaz Publication, Hyderabad
Reference Books	
1	Statistics for Advanced Level, Miller, J. (1989), Cambridge University Press.
2	Statistical Methods, Snedcor, G.W. and Cochran, W.G. (1982), Academic Press.
3	Practical Statistics for Experimental Biologists. Wardlaw, A.C. (1985), Wiley Chichester
4	Research Methodology – Methods and Techniques. Kothari, C.R. (1989), Wiley Eastern,
5	Introduction to Research Methodology in Agricultural and Biological Sciences, Venkatasubramanian, V. (1999), New Century Book House
6	Quantitative Techniques, Kothari, C.R. (1996), Vikas Publishing Housing Pvt Ltd, Hyderabad.
7	Environmental Science Methods, Haynes, R. (1982), Chapman & Hall, London.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/104/111104120/
2	https://nptel.ac.in/courses/111/106/111106112/

Course Designed By: Dr. A. Manimekalan and Dr. J. Manivannan

Mapping with Programme Outcomes										
COs/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	M	M	L	L	M	L	L	M
CO2	M	S	M	M	L	M	S	M	M	S
CO3	M	S	M	M	L	M	M	L	L	S
CO4	M	S	M	L	L	L	S	L	L	S
CO5	M	S	M	M	L	L	S	L	L	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA13D	INSTRUMENTAL METHODS OF ANALYSIS	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Basic knowledge on bioinstruments	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To understand the principles, instrumentation and application of various spectroscopic techniques based equipment for evaluating the morphological, qualitative and quantitative characteristics of environmental samples and pollutants.
2. To understand the extraction, isolation and characterization of different environmental samples through chromatographic and electrophoretic techniques.
3. To understand the radiochemical techniques and application in environmental studies.
4. To understand and monitor the level of several environmental pollutants using electro chemical techniques.
5. To understand the weather condition, composition of air pollutants and their levels in atmosphere through instrumental techniques.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the basic principles, working phenomena and application of various sophisticated equipment	K2
2	Separate, identify and characterize the various environmental samples at molecular and ionic species level	K3
3	Execute quantitative and qualitative analyses of various environmental samples through instrumentation techniques	K3
4	Evaluate the level of pollutants in soil, water, air and organisms by using analytical instruments.	K4
5	Monitor and evaluate the level of different environmental parameters and pollutants with the comparison of authentic national, international and regional standards through analytical techniques.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Spectroscopic Techniques	14 - hours

Properties of EMR–Basic Principles, Instrumentation and applications of: Ultraviolet – visible (UV-VIS) Spectroscopy, Infrared spectroscopy, FT-IR, Flame Spectrometry, Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma Emission Mass Spectroscopy (ICP-MS), Mass spectrometry (MS), Nuclear Magnetic Resonance Spectroscopy (NMR), Electron Paramagnetic Resonance (EPR), Flourimetry, Chemiluminescence's Detector System, X-Ray Fluorescence, Microscopy, SEM, TEM.

Unit:2	Chromatographic Techniques	14 - hours

Basic principles, Instrumentation and applications of Chromatography – Paper, Thin Layer Chromatography (TLC), Gel Permeation Chromatography, Ion Exchange Chromatography, High

Performance Liquid Chromatography (HPLC),Gas Chromatography(GC), Electrophoresis-SDS-PAGE, Agarose Gel Electrophoresis, 2D-Electrophoresis, PCR, Types of Centrifuge, High Speed Refrigerated Centrifuge.		
Unit:3	**Radiochemical Analysis**	**14 - hours**
Types of radiation – radioactive decay; Carbon dating; Radioactive labeling – Isotope dilution, Radiation detectors – Geiger Muller Counter, Scintillation Counters; Application of isotopes in biological and environmental studies, Neutron Activation Analysis.		
Unit:4	**Electrochemical Techniques**	**14 - hours**
Introduction to Techniques – Basic principles, Instrumentation and applications of Conductometry, Potentiometry – Ion Selective Meter – Voltammetry – Polarography, Coulometry.		
Unit:5	**Environmental and Atmospheric Monitoring Techniques**	**14 - hours**
Turbidimetry, Nephelometry, Gravimetry, Elemental Analyzer, TOC Analyzer, Portable Gas Analysis – H_2S, CO_2, SO_2, O_3, HC, Particulate Analysis, Stack Monitoring, Meteorological Equipments.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, case studies, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Vogel's Text Book of Quantitative Inorganic Analysis, Barnes, J.D. J., Denney, R.C., Jeffery, G.H. and Mendham, J. (1999), 6th Edition, Pearson Education Ltd., U.K.
2	Instrumental Methods of Chemical Analysis, Sharma, B.K. (2005), Goel Publishing House, Meerut., India.
3	Instrumental methods of analysis, Malathi, S., Patil, P. M., Kumar, S. (2020). Thakur publications (pvt.) Ltd, Lucknow, India
4	Instrumental Methods of Analysis, Chatwal, G. R. and Anand, S. K. (2018). Himalaya Publishing House, Delhi.
5	Instrumental Methods Of Analysis, 7th edition , Hobart H. Willard, Lynne L. Merritt, John A. Dean and Frank A. Settle, Jr. , (Eds.). (1986), CBS Publishers & Distributors, New Delhi
Reference Books	
1	Standard Methods for the Examination of Water and Wastewater, (1998), 23rd, Edition, APHA, Washington, D.C.
2	Environmental Monitoring and Instrumentation, Bucholtz, F. (1997), Optical Society of America, Washington D.C.
3	Environmental Sampling Analysis: A Practical Guide, Keith, L.H. (1991), 3rd Edition, Lewis Publication, Boca Raton, Florida.
4	Handbook of Analytical Instruments, Khandpur, R. S. (2015), 3rd Edition, McGraw Hill Education (India) Private Limited, New Delhi.
5	Fundamentals of Analytical Chemistry, Skoog, D. A. and West, D.M. (2004), Thomson Asia Pvt Ltd, Singapore.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/103/108/103108100/
2	https://onlinecourses.nptel.ac.in/noc20_ch02/preview
Course Designed By: Dr. P. Siddhuraju	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	S	M	M	S	M	M	M	M
CO2	S	M	S	L	M	M	S	S	M	S
CO3	M	M	S	M	M	S	M	M	S	M
CO4	S	L	M	L	S	S	M	S	M	S
CO5	S	M	M	S	M	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA1EA	ECOLOGY	L	T	P	C
Core/Elective/Supportive		Elective-1a	4	0	0	4
Pre-requisite	Basic knowledge on plant and animal science	Syllabus Version	2020-2021			

Course Objectives:

The main objectives of this course are to:

1. Impart knowledge on the fundamentals of Ecology
2. Understand the natural environment
3. Study the relationship between organisms and their surroundings

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Have a basic understanding on the fundamentals of Ecology.	K2
2	Understand energy in the ecological systems.	K2
3	Have sound knowledge on population ecology, community ecology including landscape ecology.	K2
4	Have the skill to interpret the limiting and regulatory factors that influence functioning of the Ecosystem.	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Introduction to Ecology	14 - hours

Ecology: History and Relevance to Humankind, Levels-of-Organization Hierarchy, The Emergent Property Principle, Transcending Functions and Control Processes, Ecological Interfacing. Concept of the Ecosystem and Ecosystem Management, Tropic Structure of the Ecosystem, Gradients and Ecotones, Techno ecosystems, Concept of the Ecological Footprint.

Unit:2	Energy in Ecological Systems	14 - hours

Fundamental Concepts Related to Energy, Solar Radiation and the Energy Environment, Concept of Productivity, Energy Partitioning in Food Chains and Food Webs, Metabolism and Size of Individuals, Net Energy Concept, Energy-Based Classification of Ecosystems, Energy Futures, Energy and Money.

Unit:3	Limiting and Regulatory Factors	14 - hours

Concept of Limiting Factors, Factor Compensation and Ecotypes, Conditions of Existence as Regulatory Factors, Fire Ecology, Other Physical Limiting Factors, Biological Magnification of Toxic Substances, Anthropogenic Stress as a Limiting Factor for Industrial Societies.

Unit:4	Population Ecology	14 - hours

Properties of the Population, Basic Concepts of Rate, Intrinsic Rate of Natural Increase, Concept of Carrying Capacity, Population Fluctuations and Cyclic Oscillations, Density-Independent and Density-Dependent Mechanisms of Population Regulation, Patterns of Dispersion, Home Range and Territoriality, Metapopulation Dynamics, *r*- and *K*-Selection.

Unit:5	**Community Ecology**	**14 - hours**
Types of Interaction between Two Species, Coevolution, Evolution of Cooperation, Interspecific Competition and Coexistence. Interactions: Predation, Herbivory, Parasitism, Allelopathy, Commensalism, Cooperation, Mutualism. Concepts of Habitat, Ecological Niche, and Guild. Ecosystem Development-Concept of the Climax. Landscape Ecology.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Fundamentals of Ecology, Fifth Edition, Odum, E. P. and Barrett, G.W. (2004), Brooks Cole, Belmont, CA.
2	Ecology, Russell, P.J., Wolfe, S.L., Hertz, P.E., Starr, C. And McMillan, B. (2008), Brooks Cole, Course Technology, Cengage Learning India Private Limited, New Delhi.
Reference Books	
1	Essentials of Ecology and Environmental Science, Rana, S.V.S. (2005), 2nd Edition, Prentice Hall of India, New Delhi.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://shodhganga.inflibnet.ac.in/bitstream/10603/135902/7/07_chapter%20i.pdf
2	https://www.nature.com/scitable/knowledge/library/energy-economics-in-ecosystems-13254442/
3	https://biologydictionary.net/limiting-factor/
4	https://web.ma.utexas.edu/users/davis/375/popecol/lec1/whatis.html
5	https://openoregon.pressbooks.pub/envirobiology/chapter/4-4-community-ecology/

Course Designed By: Dr. L. Arul Pragasan

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	S	S	M	L	M	M	M	M
CO2	S	M	M	S	M	M	L	M	M	M
CO3	M	M	M	S	M	L	M	S	M	S
CO4	M	S	M	S	M	L	M	M	M	M

*S-Strong; M-Medium; L-Low

Course code	20ENVA1EA	NATURAL RESOURCES MANAGEMENT	L	T	P	C
Core/Elective/Supportive		Elective-1b	4	0	0	4
Pre-requisite		Basic knowledge on the environmental issues and its related information	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To enrich the knowledge on natural resources and their significance and to know the strategies for sustainable management
2. To discuss the process of recognizing and defining NRM issues within an ecosystem management Framework
3. To explains with an analysis of the role of ethics, social justice, and communication in the sustainable management of natural resources.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Gain a thorough knowledge of natural resources, their distribution and factors affecting their availability.	K2
2	Understand how developmental activities will affect the natural resources of a nation.	K3
3	Understand the importance of natural resources, the need to conserve them and can attempt for alternative energy sources.	K4
4	Create awareness to incorporate best management plans in planning activities for nature conservation and sustainable environmental protection.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Natural Resources	14 - hours

Concept and types of natural resources, classification of natural resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. Concern on Productivity issues - ecological, social and economic dimension of resource management.

Unit:2	Land and Water Resource	14 - hours

Soil types, profile and composition, degradation of land and soil- agricultural lands - Land use and land cover, impacts of land use on environment – man-induced landslides; wetland ecology & management. Major water resources- surface and ground water - distribution and supply-hydrological cycle, Causes of water resource depletion - Use and over use of water resources, water resource management - Ground water recharging, rain water harvesting; Watershed management Concept, and objectives, flood control-Dams; Wetlands: definition, importance and classification.

Unit:3	Mineral and Energy Resources	14 - hours

Types, distribution and reserves of mineral resources, - use and exploitation - environmental effects

of mining – case studies - Resource extraction, access and control system – Ecological, economic, and ethnological approach and their implications; integrated resource management strategies.		
Unit:4	**Forest and Energy Resource**	**14 - hours**
Types and extent of forests in India - deforestation and conservation strategies; Importance of natural areas - carbon sequestration; forest fragmentation, national forest policy; Biodiversity-conservation strategies, global biodiversity hotspots; threatened and endemic species-Developing and developed world strategies for forestry. World energy demand – renewable, non-conventional, nuclear energy, tidal energy- alternate energy sources- solar and wind energy- Oil and natural gas, coal, biomass energy, geothermal energy, hydropower; Environmental implication of energy use.		
Unit:5	**Management of Common International Resources**	**14 - hours**
Ocean, Climate, International fisheries and management commissions; Antarctica: the evolution of an international resource management regime – case studies – Resource management in mountain ecosystem – management of marine and coastal ecosystem.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Global Biodiversity: Status of the Earth's Living Resources, World conservation Monitoring Centre, Groombridge, B. (2010), UNEP, Cambridge.
2	The Environment, Raven, P.H. and Berg, L. R. (2011), 8th Edition, Wiley, UK.
3	Resource Ecology, Agarwal, S. K. (1993), Himanshu Publications. Delhi.
4	Ecology of Natural Resources, Ramade, F. (1984), John Wiley& Sons Ltd.
5	Fundamentals of Ecology, Odum, E. P. (1971),W.B. Saunders Co. USA.
6	Monitoring Sustainability: Indices and Techniques of Analysis, Ramachandran, N. (2000). Concept Publishing Company, New Delhi.
7	Coastal Ecology & Management, Ecology of Coastal Waters with implications for Management (2nd Edition).Chap. 2-5, pp.18-78 & Chap. 16, pp.280-303,Mann, K.H. (2000), Wiley-Blackwell
Reference Books	
1	Global Change and Natural Resource Management, Vitousek, P.M. (1994), Beyond global warming: Ecology and global change. Ecology 75, (7), 1861-1876.
2	Environmental Biology, Agarwal, K. C. (2001), Nidhi Publication Ltd., Bikaner.
3	Environmental Encyclopedia, Cunningham, W.P., Cooper, T.H., Gorhani, E. and Hepworth, M.T. (2001), Jaico Publishing House.
4	Global Biodiversity Assessment, Heywood, V.H. and Watson, R.T. (1995), Cambridge University Press.
5	Introduction to Environmental Science, Anjaneyulu, Y. (2004), B S. Publications, Hyderabad
6	Environmental Science, Miller T.G. Jr. (1989), Wadsworth Publishing Co. (TB)
7	Essentials of Ecology, Townsend, C.R., Begon, M. and Harper, J. L. (2008), 3rd edition, Blackwell Science.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://onlinecourses.swayam2.ac.in/cec20_hs10/preview
2	https://www.mooc-list.com/tags/natural-resource-management.
Course Designed By: Dr. M. Muniasamy	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	M	M	S	S	S	S
CO3	S	M	M	M	S	S	M	S	M	M
CO3	M	S	S	M	S	S	M	S	S	M
CO4	M	S	M	M	S	M	M	M	S	M

*S-Strong; M-Medium; L-Low

Second Semester

Course code	20ENVA23A	ENVIRONMENTAL IMPACT ASSESSMENT AND GREEN AUDITING	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Basic knowledge in environmental impact assessment	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Introduce students to the concept of Environmental Management
2. Develop skills in identifying and solving environmental problems
3. Teach the principles and practices of effective environmental management system audits

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Explain the concepts about Environmental Impact Assessment, develop skills in identifying and solving problems	K2
2	Locate, analyse and evaluate informations from various environmental matrices systematically	K4
3	Be able to access and analyse different case studies/examples of EIA in practice for evaluation/assessment	K4
4	Explain the importance of environmental audits and other management tools in business for social benefit by improving environmental performance	K3
5	Calculate the carbon footprint of any organization and identify suitable mitigation strategies for carbon reduction solutions.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	EIA objectives	14 - hours

Basis for Environmental Impact Assessment– Screening of Projects – Environmental Assessment Procedures –Significant Impact–Project Alternatives. Environmental Impact Statement Process – Environmental Management Plan (EMP).Guidelines for environmental audit, EIA Notification – 2006 and amendments. Public Participation, Regional and Sectoral Impact Assessment, Major limitations of Environmental Impact Assessment. Status of EIA in India -Current trends and strategies.

Unit:2	EIA Methodologies	14 - hours

Adhoc Method – Checklist Methods – Matrix Methods – Network Methods, Uniqueness ratio, habitat evaluation system. Prediction and Assessment of Impacts on Natural Resources – Biota, Surface Waters, Ground Water, Air, Noise, Hazards, Historic and Cultural Resources, Transportation, Socio-economic relationships.

Unit:3	EIA Case Studies	14 - hours

Land Clearing Projects – Dam sites –Aquaculture– Mines–Steel–Hydel–Thermal–Nuclear–Oil and Gas based Power Plants – Highways projects – Industrial Projects. Inter linking of Rivers and River Basin Management.

Unit:4	**Green Auditing**	**14 - hours**
Introduction, Necessity, Procedure for Environmental Auditing, Case Study. Environmental Management System- ISO 14000 series of standards. Green Entrepreneurship- Green Consumerism, Green Technology. Certification Process – Different Phases of Audit, Certification Audit. Various Certifying Agencies in Operation.		
Unit:5	**Carbon Sequestration**	**14 - hours**
Sources and Sinks, Biological Processes, Physical Processes, Chemical Processes. Greenhouse Gas Emissions, Kyoto Protocol, Carbon Footprint, Carbon Trading, Carbon Diet, Carbon Credits, Role of Trees and Forest in Reducing Atmospheric Carbon.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)

1	Environmental Impact Assessment, Canter, L.W. (1996), McGraw Hill, New York.
2	Environmental Audit, Shrivastava, A. K. (2003), New Delhi, India
3	Environmental Impact Assessment- A Comprehensive Guide to Project and Strategic Planning, Eccleston, C. H. (2000), John Wiley and Sons.
4	Introduction to Carbon Capture and Sequestration, Smit, B., Reimer, J. A., Oldenburg, C. M. and Bourg, I. C. (2014), Imperial College Press, London.

Reference Books

1	Environmental Impact Statements, Bregman, J. I. (1999), Lewis Publishers, London.
2	Environmental Assessment, Singleton R, Castle, P and Sort, D. (1999), Thomas Telford Publishing, London.
3	Effective Environmental Assessment, Eccleston, C. H. (2000), Lewis Publishers, London.
4	Environmental Auditing, Humphery, N. and Hadley. M. (2000), Boca Raton, USA.
5	Green Accounting, Bartelmus, P. and Seifert, E. K. (2017), Taylor & Francis Limited.
6	Perspectives in Environmental Studies, Kaushik, A. and Kaushik C. P. (2014). 4th Edition, New Age International Publishers, New Delhi.
7	Carbon Sequestration for Climate Change Mitigation and Adaptation, Ussiri, D. A. N. Lal, R. (2017), Springer International Publishing.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/120/108/120108004/
2	https://www.iisd.org/learning/eia/eia-essentials/timeline/
3	https://www.open.edu/openlearn/nature-environment/organisations-environmental-management-and-innovation/content-section-2.8

Course Designed By: Dr. L. Arul Pragasan, Dr.J.Manivannan

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	S	S	S	S	S	L	S
CO3	S	S	S	S	S	S	S	S	M	S
CO3	M	S	S	S	S	S	S	S	L	S
CO4	M	M	M	S	S	S	S	S	L	S
CO5	S	M	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA23B	ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Knowledge in basic microbiology	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Impart knowledge on microbial diversity and recent advancement methods in the analysis of microbial diversity.
2. Provide in-depth knowledge of role of beneficial and pathogenic microorganisms in environment.
3. Understand the application of microbes for production of different eco-friendly products.
4. Impart knowledge in molecular biotechnology and its applications in Environmental management and conservation of biodiversity.
5. Make students aware about Bioethics, biosafety and IPR.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand and describe the type of microorganisms in the environment and the role of microorganisms in the cycling of nutrients in an ecosystem.	K2
2	Relate the role of micro-organisms in spread of human diseases and select the type of physical and chemical agents for microbial control.	K3
3	Understand the importance of plants and microbes in environmental remediation	K3
4	Know the ethical guidelines in use of GMOs, different biosafety levels and IPR.	K3
5	Know the importance of microbes and biotechnology for the synthesis of ecofriendly products.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Distribution / Diversity of Microorganisms	14 - hours

Microflora in different aquatic and terrestrial environment; Adaptation of microorganisms to the air environment; Extreme Environment – archae bacteria, acidophilic, alkalophilic, thermophilic, barophilic, osmophilic and radiodurant microbes. Role of Microorganism in Biogeochemical cycles - Nitrogen, Carbon, Phosphorus, Sulphur Cycle, Microbial corrosions.

Unit:2	Ecological Relationships Among the Microorganisms	14 - hours

Relationship among microbial population, microbial interactions in a biofilm, Host - Microbe interaction (Beneficial and pathogenic), Microbial pathogens and Parasites and their effects on Human, Animal and Plant health, Transmission of pathogens – Bacterial, Viral, Protozoan, and Helminths, Control of microorganisms. Indicator microorganisms in air, water and soil Environment-Standard criteria of indication; Bio-indication of water quality.

Unit:3	Microbes-Molecular Approaches and Applications	14 - hours

Understanding microbial diversity in the environment by culture-dependent approaches and their limitations, and by culture-independent molecular approaches (BIOLOG microtitre plates, analysis of

FAME profiles, quantitative PCR (qPCR), and fluorescent in situ hybridization, pyro sequencing). Role of microbes in production of Biofuel, Biosurfactants, enzymes, biopolymers and biodegradable plastics.		
Unit:4	**Role of Biotechnology in Environmental Protection**	**14 - hours**
Development of genetically engineered microorganisms (GEMs), Role of GMOs in bioremediation, Advantages of Genetically engineered plants; Bt insecticide; Conservation of bio-diversity by gene banks, Reforestation through micro-propagation. Microbial enhanced oil recovery (MEOR), Biomining, biosensors, Nano technology in pollution control.		
Unit:5	**Bioethics, Biosafety and IPR**	**14 - hours**
Ethics of Genetically modified plants, animals, microbes, GM food and Biowarfare. Biosafety guidelines in India; Containment, bioaerosol control and different biosafety levels. Intellectual Property Rights -patents- Plant variety protection (PVP) - Plant breeders rights (PBRs)-Genetic use restriction technology (GURT).		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)

1	Textbook of Environmental Microbiology, Mohapatra, P. K. (2008), I.K. International (P)Ltd.
2	Environmental Microbiology, Pepper, I. L., Gerba, C. P. and Gentry, T. J. (2015), 3rd edition, Academia Press, Elsevier
3	Basic Biotechnology, Ratledge, C. and Kristiansen, B. (2003), 2nd edition, Cambridge University Press
4	Bioethics and Biosafety in Biotechnology, Sree Krishna.V. (2007), New Age International Publishers.

Reference Books

1	Topics in Ecological and Environmental Microbiology, Schmidt, T. M. and Schaechter, M.(2012), 3rdedition, Academia Press, Elsevier.
2	Environmental Microbiology: Fundamentals and Applications: Microbial Ecology, Bertrand, J. C., Caumette, P. and Lebaron, P. (2015), Springer
3	Environmental Microbiology – Theory and Application, Jjemba, P.K. (2004), Science Pub. Inc., USA.
4	Environmental Biotechnology-Theory and Application, Evano, G.H. and Furlong, J.C. (2004), John Wiley and Sons, USA
5	Environmental Biotechnology and Cleaner Bioprocesses, Olguin, C. J., Sanchez, G., Hernandez. E. (2000), Taylor & Francis

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://www.researchgate.net/publication/51905295_Culture-independent_methods_for_studying_environmental_microorganisms_Methods_application_and_perspective

2	https://www.hindawi.com/journals/ijps/2015/326745/
3	https://pubmed.ncbi.nlm.nih.gov/23190337/
4	https://www.sciencedirect.com/science/article/pii/S0960852418304310?via%3Dihub
5	https://www.sciencedirect.com/science/article/pii/S0734975010000728
6	https://www.sciencedirect.com/science/article/pii/S0167779917301051
7	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6100491/
Course Designed By: Dr. M. Rajkumar & Dr. B. Sathya Priya	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	L	M	M	M	M	L	S	L
CO3	L	M	S	L	L	M	S	M	M	M
CO3	L	S	S	S	M	S	S	S	S	S
CO4	M	S	M	S	M	S	S	S	S	S
CO5	M	M	S	S	L	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA23C	BIODIVERSITY AND CONSERVATION	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Must have basic knowledge on Biology	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

To impart understanding on the occurrence and distribution of various flora and fauna, their existence, interaction, Importance of biodiversity conservation and understand about Legislation related to conservation.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Student will gain knowledge about the diversity distribution pattern of the enormous number of species and different kind of ecosystems in the natural world.	K1&K2
2	The interaction between the various species and environment and the impact of social development on biodiversity	K3
3	The importance of conservation of biodiversity which serving to the mankind and the ecosystem, and the major threats to biodiversity due to human developmental activities. The loss of biodiversity and the impact to the humankind.	K4
4	Will gain knowledge about legislations regarding the conservation of biodiversity.	K5
5	Will gain knowledge on Conservation and Management of biodiversity	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Scope and Constraints of Biodiversity Science	14 - hours

Biological Diversity: Species – Origin of new species, Description of new species, Community and ecosystem diversity, Genetic diversity- The Hardy-Weinberg law; genetically effective populations size, Gene flow-Genetic pollution and gene erosion, Systematics in Diversity – Environment and Genetic Variations – Biological Classification – Phylogenetic Relationship – Ecological Biodiversity –Species Concept – Biological and Phylogenic Concepts; Species Inventory – Biodiversity hot spots. IUCN categories– Red data book. Case Studies – Deciduous Forests - Desert Lizard communities – Marine and Coral Reef - Fish Communities -Island species — Western and Eastern Ghats – Himalayas.

Unit:2	Species Diversity	14 - hours

Global Distribution of Species - Tropical species diversity – Diversity in terrestrial, marine and freshwater –Micro-organisms-lower and higher plants – lower and higher invertebrates and vertebrates; Species extinction and Endangered species; Monitoring indicator species and habitats; Threats to biodiversity: Extinction – Past rate of Extinction – Human Caused Extinctions – Endemic species - Extinction rates - Man and animal conflicts.

Unit:3	**Habitats and Ecosystem**	**14 - hours**
History of ecosystem ecology, Human induced Ecosystem change, Urban Ecosystem Classification – Ecosystem mapping, tropical forests, grasslands, wetlands, coral reefs, mangroves; Habitat lass: Habitat destruction – Fragmentation and degradation – desertification – Habitat restoration; Invasive Species: their introduction pathways, biological impacts of invasive species on terrestrial and aquatic systems; Pollution: Impacts of Pesticide pollution, Water pollution and Air Pollution on biodiversity; Overexploitation: Impacts of Exploitation on Target and Non-target Terrestrial and Aquatic species and Ecosystems.		
Unit:4	**Values of Biodiversity**	**14 - hours**
Instrumental/Utilitarian value and their categories, Direct use value; Indirect/ Non-consumptive use value, Introduction to Ecological Economics; Monetizing the value of Biodiversity; Intrinsic Value; Ethical and aesthetic values, Anthropocentrism, Biocentrism, Ecocentrism and Religions; Intellectual Value; Economics of Ecosystem, Green Revolution, Food Plants, medicinal and ornamental plants, animal uses – livestock and fisheries.		
Unit:5	**Conservation and Management**	**14 - hours**
National Legislation – Protection of Wild flora and Fauna -Protection of National Habitats - National and International Protected Areas – Current Practices in Conservation - in *situ* Conservation and *ex situ* Conservation of Threatened Species – Biodiversity Act 2002 – Patent Act – Agenda 21 – Forest protection Act-Forest conservation Act 1980-Multilateral Treaties – Biodiversity Conventions. Environmental ethics – Biodiversity – a Socio – Political Perspective; Community conserved Areas (CCAs) - Range sand significance of CCAs.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars– webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)

1	Global Biodiversity – Status of the Earths Living Resources, Groombridge, B. (1992), Chapman & Hall, London.
2	Ecology of Natural Resources, Ramade, F. (1991), John Wiley and Sons Ltd.
3	Global Biodiversity and Strategy, WRI, IUCN, UNEP (1992).
4	Biodiversity, Science and Development, Younes, T and Castri, F. (1996), CAB International, UK.
5	The Biology of Biodiversity, Kato, M. (1999), Springer Verlag, Tokyo.
6	Biodiversity Conservation – In Managed forest and Protected areas, Kotwal, P.C. and Banerjee, S. (2002), Agrobios, India.
7	Global Biodiversity, Sinha, R. K. (1997), INA Shree Publishers, Jaipur.
8	Mega diversity Conservation, flora, Fauna and Medicinal Plants of India's hot spots, Chaudhuri, A. B. and Sarkar, D. D. (2003), Daya Publishing House, New Delhi.
9	Conservation of Biodiversity and Natural Resources. Singh, M.P., Singh B.S. and Dey, S.S. (2004), Daya Publishing House, New Delhi.
10	Biodiversity –Strategies for Conservation, Dadhich L. K. and Sharma, A.P. (2002), APH Publishing Corporation, New Delhi

11	Global Biodiversity – Conservation Measure, Khan, T. I and Al-Ajmi, D. N. (1999), Pointer Publishers, Jaipur.
12	An Advanced Textbook on Biodiversity – Principles and Practice, Krishnamurthy, K.V. (2003), Oxford and IBH Publishing, New Delhi.
13	An advanced Text book on biodiversity, Krishnamurthy, K. V.(2003), Oxford and IBH Book Publishing Co Pvt Ltd., New Delhi.
14	Evolution, Hall, B. K. and Hallgrimsson, B. (2014), 5th Edition, Johnes and Bartlett India Pvt. Ltd. New Delhi.
15	Ridley, M.(2004), Evolution, 3rd Edition, Blackwell Science Ltd a Blackwell Publishing company, USA,
16	Curry, G.B. and. Humphries C. J. (2007), Biodiversity Databases Techniques, Politics, and Applications, CRC Press, Taylor & Francis Group.
17	The conservation of Plant Biodiversity, Frankel, O. H., Brown, A.H.D.and Burdon, J.J. (1995), 1st edition, Cambridge University Press.
18	Encyclopedia of Biodiversity, Levin, S.A. (2000), Volume 1, Academic Press.
19	Manual of patent Practice and procedure Patent office, India, 2005.
20	Evolution Understanding Evolution http:// evolution. berkeley.edu /evolibrary/ article/ evo_01 accessed on 28.12.2014.
Reference Books	
1	Geologic Time and Earth's Biological History ftp://ftpdata.dnr.sc.gov /geology/Education/PDF /Geologic%20Time.pdf .
2	Center of origin - Wikipedia, the free encyclopedia en.wikipedia.org/wiki/Centeroforigin accessed on 28.12.2014
3	Biodiversity Hotspots - http://en.wikipedia.org/wiki/Biodiversity_hotspot accessed on 28.12.2014.
4	Plant Genetic Resources: Otto, H., Anthony, H.D., Brown and Burdon J.J. (1995).
5	The Conservation of Plant Biodiversity, 1st edition, Cambridge University Press
6	Megadiverse Countries; http:// geography. about.com/od/ physicalgeography /a/Megadiverse - Countries. htm accessed on 28.12.2014.
7	Geo data base Standards: www.data. gov.bc.ca/local/dbc /docs/geo/services/ standards procedures/ file_geobase_standards.pdf accessed on 31.12.2014.
8	Barcode Standards: barcoding.si.edu/pdf/dwg_data_standards-final.pdf accessed on 31.12.2014
9	UNESCO http://en.wikipedia.org/wiki/Biosphere_reserves_of_India accessed on 31.12.2014
10	Biodiversity Databases Techniques, Politics, and Applications, Curry, G.B. and Humphries, C. J. (2007), CRC Press, Taylor & Francis Group. Frankel,
11	UNIT V: Biodiversity Economics, Legislation and Intellectual Property Rights (IPR):
12	Environmental and Forest Acts, TRIPS, UPCOV, Suigeneris systems, Plant Breeders

13	Conservation, Management and use of Agrobiodiversity naasindia.org/Policy% 20Papers /pp4.pdf
14	PPV & FRA http://www.plantauthority.in/ accessed on 31.12.2014
15	Patent office of India http://www.ipindia.nic.in/ accessed on 31.12.2014
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	Wildlife Conservation- https://onlinecourses.nptel.ac.in/noc19_bt32/preview
2	Ecology and Wildlife Conservation – https://www.mooc-list.com/course/ecology-and-wildlife-conservation-futurelearn
3	Biological Diversity (Theories, Measures and Data sampling techniques) https://www.mooc-list.com/tags/biodiversity
Course Designed By: Dr. A. Manimekalan	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	M	M	M	L	M	M	S	M
CO2	M	M	L	S	M	M	M	M	S	L
CO3	L	M	M	M	S	M	L	L	S	M
CO4	M	S	L	M	S	M	M	M	M	L
CO5	L	M	M	M	S	L	L	M	S	M

*S-Strong; M-Medium; L-Low

Course code	20ENVA23D	INTRODUCTION TO INDUSTRY 4.0	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Basic knowledge on computational methods	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Educate the students about industry 4.0 tools
2. Impart knowledge on Big data analysis
3. Impart knowledge on Artificial Intelligence and Internet of Things with Environmental Sciences perspectives

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the need for adopting Industry 4.0 tools	K2
2	Understand the basics of Artificial Intelligence and associated technologies	K2
3	Understand the basics of Big data analytics	K2
4	Understand the basics of Internet of Things	K2
5	Apply the tools of Industry 4.0 in various disciplines	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Industry 4.0	14 - hours

Need – Reason for Adopting Industry 4.0 - Definition – Goals and Design Principles -Technologies of Industry 4.0 – Big Data – Artificial Intelligence (AI) – Industrial Internet of Things - Cyber Security – Cloud – Augmented Reality.

Unit:2	Artificial Intelligence	14 - hours

Artificial Intelligence: Artificial Intelligence (AI) – What & Why? - History of AI -Foundations of AI -The AI - Environment - Societal Influences of AI – Application Domains and Tools - Associated Technologies of AI - Future Prospects of AI - Challenges of AI

Unit:3	Big Data and IOT	14 - hours

Big Data : Evolution - Data Evolution - Data : Terminologies - Big Data Definitions - Essential of Big Data in Industry 4.0 - Big Data Merits and Advantages - Big Data Components : Big Data Characteristics - Big Data Processing Frameworks - Big Data Applications - Big Data Tools - Big Data Domain Stack : Big Data in Data Science – Big Data in IoT - Big Data in Machine Learning - Big Data in Databases - Big Data Use cases: Big Data in Social Causes - Big Data for Industry -Big Data Roles and Skills -Big Data Roles - Learning Platforms; Internet of Things (IoT) : Introduction to IoT – Architecture of IoT - Technologies for IoT - Developing IoT Applications - Applications of IoT -Security in IoT

Unit:4	Applications and Tools of Industry 4.0	14 - hours

Applications of IoT – Manufacturing – Healthcare – Education – Aerospace and Defense – Agriculture – Transportation and Logistics – Impact of Industry 4.0 on Society: Impact on Business, Government, People. Tools for Artificial Intelligence, Big Data and Data Analytics, Virtual Reality,

Augmented Reality, IoT, Robotics		
Unit:5	**Jobs 2030**	**14 - hours**
Industry 4.0 – Education 4.0 – Curriculum 4.0 – Faculty 4.0 – Skills required for Future - Tools for Education – Artificial Intelligence Jobs in 2030 – Jobs 2030 - Framework for aligning Education with Industry 4.0		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars, case studies - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	P. Kaliraj, T. Devi, Higher Education for Industry 4.0 and Transformation to Education 5.0, 2020
Reference Books	
1	Data Analytics and Big Data. Soraya Sedkaoui (2018). Wiley Press
2	Big Data: A Very Short Introduction, Dawn E. Holmes (2017). Oxford Press
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/106/104/106104189/
2	https://nptel.ac.in/courses/106/102/106102220/
3	https://onlinecourses.nptel.ac.in/noc20_cs92/preview
Course Designed By: Dr. J. Manivannan	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	S	M	L	L	M	L	L	M
CO2	L	S	S	M	L	L	S	L	L	M
CO3	L	S	S	M	L	L	S	L	L	S
CO4	L	S	S	M	S	S	S	L	S	S
CO5	L	S	S	S	L	L	M	M	L	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA2EB-1	NATURAL HAZARDS AND DISASTER MANAGEMENT	L	T	P	C
Core/Elective/Supportive		Elective-2a	4	0	0	4
Pre-requisite		Basic Aptitude in Natural Hazards and Disaster	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To educate the students about the different types of natural hazards and understand approaches
2. To understand the disaster preparedness, mitigation and risk reduction.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Will be able to understand and differentiate the different types of disasters, analyse the causes and their potential impact on the natural and man-made environments.	K1& K2
2	Will be able to create awareness among the vulnerable population as a measure of disaster mitigation	K6
3	Educate people about the importance of preparedness in vulnerable areas.	K3
4	will be able to know about the various national and international agencies that play a major role in disaster management	K2
5	The knowledge gained will enable the students to volunteer themselves in disaster management programs thus helping affected community.	K4& K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Natural Disasters	14 - hours

Educative – trends in climatology, meteorology and hydrology. Seismic activities. Changes in Coastal zone, coastal erosion, beach protection. Coastal erosion due to natural and manmade structures.

Unit:2	Types of Disasters	14 - hours

Nature and characteristics Cyclone – Tornadoes – Avalanches – Flood –Drought – Volcanic – Earthquakes – Fire – Landslides – Causes and effects - Impact on Environment Forecasting and Warning System – Disaster Profile of India

Unit:3	Disaster Management	14 - hours

Predisaster Planning-Toning of Disaster – prone areas – prioritization –regulations – protection measures during disaster and Post disaster. Relief Camp Organization –Survey and Assessment. Disaster Management Cycle – Vulnerability Analysis – Disaster Training – Legal Aspects – case studies for disasters and management. Technology for Disaster Management – Role of Information and communication technology, GPS, Remote sensing and Geographic Information system in Disaster Management.

Unit:4	Disaster Preparedness and Training	14 - hours

Community Preparedness in Natural Disasters- Role of information, education, communication and training- Roles and responsibilities of different national and international agencies and government -

NGO, Armed forces, Paramilitary forces, Community based organizations (CBO) - Army Training for Disaster Reduction –Role of team and co-ordination -Training needs.

Unit:5	**Mitigation Strategies**	**14 - hours**

Disaster Mitigation – Trends in disaster management - UN draft resolution on Strengthening of Coordination of Humanitarian Emergency Assistance, International Decade for Natural Disaster Reduction (IDNDR), Policy for disaster reduction, problems of financing and insurance. Training for emergency, Regulation/guidelines for disaster tolerance building structures.

Unit:6	**Contemporary Issues**	**2 - hours**

Expert lectures, online seminars, case studies - webinars

	Total Lecture hours	**72 - hours**

Text Book(s)

1	Natural Disaster, Sharma, R. K. & Sharma, G. (2005), APH Publishing Corporation, New Delhi.
2	Earthquake: A Natural Disaster, Ashutosh, G. (1994), Ashok Publishing House, New Delhi.
3	Natural Hazards and Disaster Management -Vulnerability and Mitigation, Singh. R. B, (2006), Rawat Publications, New Delhi.

Reference Books

1	Natural Hazards, Edwards, B. (2005), Cambridge University Press, U.K.
2	Early warning Systems for Natural Disaster Reduction, Zschau, J. and Kuppers, N. (2003), Springer-Verlag, Berlin.
3	Space Technology for Disaster management: A Remote Sensing & GIS Perspective , Roy, P.S. (2000), Indian Institute of Remote Sensing (NRSA), Dehradun.
4	A Manual on Disaster Management, Diwan, P. (2010), Pentagon Earth, New Delhi.
5	Disaster Management: A disaster Manager's Handbook, Carter, N.W. (1992), Asian Development Bank, Manila.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	www.iirs.nrsa.org
2	www.GIS. Development.net
3	http://quake.usgs.gov

Course Designed By: Dr. D. Prabha, Dr. P. Siddhuraju

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	S	M	L	S	L	S
CO2	M	M	S	M	S	S	M	S	M	M
CO3	M	M	M	M	S	S	M	S	L	M
CO4	L	M	S	S	S	M	M	S	L	M
CO5	M	M	S	S	S	M	M	M	M	M

*S-Strong; M-Medium; L-Low

Course code	20ENVA2EB-2	ENVIRONMENTAL GEOSCIENCES	L	T	P	C
Core/Elective/Supportive		Elective-2	4	0	0	4
Pre-requisite	Basic knowledge on Earth resources	Syllabus Version	2020-2021			

Course Objectives:

The main objectives of this course are to:

1. Impart knowledge on the fundamentals of natural environment
2. Understand the Earth, Geochemistry, Mineral and Water resources of the environment
3. Study about the Earth Systems and Biosphere

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Have a basic understanding on the Earth resources	K1
2	Have sound knowledge on the earth's structure, natural resources and the environment	K2
3	Understanding the Earth system of interacting rock, water, air and life and how these elements have shaped Earth's surface	K2
4	Have the skill to identify the geologic features of the earth and usethem to understand the geologic history of a region.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	The Earth Systems and Biosphere	14 - hours

Conservation of matter in various geospheres – lithosphere, hydrosphere, atmosphere and biosphere. Energy budget of the earth. Earth's thermal environment and seasons. Ecosystems flow of energy and matter. Coexistence in communities-food webs, ecosystems terrestrial and aquatic. General relationship between landscape, biomes and climate. Climates of India, Indian Monsoon, El Nino, Droughts. Tropical cyclones and Western Disturbances.

Unit:2	Earth's Processes and Geological Hazards	14 - hours

Earths processes; concept of residence, time and rates of natural cycles. Catastrophic geological hazards.Study of floods, landslides, earthquakes, volcanism and avalanche. Prediction and perception of the hazards and adjustments to hazardous activities.

Unit:3	Mineral Resources and Environment	14 - hours

Resources and Reserves, Minerals and Population. Oceans as new areas for exploration of mineral resources. Ocean ore and recycling of resources. Environmental impact of exploitation, processing and smelting of minerals.

Unit:4	Water Resources and Environment	14 - hours

Global Water Balance. Ice sheets and fluctuations of sea levels. Origin and composition of seawater. Hydrological cycle. Factors influencing the surface water. Types of water. Resources of oceans. Ocean pollution by toxic wastes. Human use of surface and ground waters. Groundwater pollution.

Land use Planning: The land use plan. Soil surveys in relation to land use planning. Methods of site selection and evaluation.		
Unit:5	**Environmental Geochemistry**	**14 - hours**
Concept of major, trace and REE. Classification of trace elements, Mobility of trace elements, Geochemical cycles. Biogeochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)

1	Geoenvironment - An introduction, Aswathanarayana, U., (1995), Capital Books.
2	A text book of environment, Agrawal, K. M, Sikdar, P. K., and Deb, S. C., (2002), 1st Edition, Macmillan India.
3	Groundwater assessment, development and management, Karanth, K.R., (1987), Tata McGraw Hill.
4	Engineering and General Geology, Singh, P. (1999), S. K. Kataria & Sons, New Delhi.
5	Environmental Geology-Indian Context, Valdiya, K. S. (1987), Tata McGraw Hill Publication. Co., Bombay.

Reference Books

1	Natural Hazard, Bryant, E. A. (1991), Cambridge University Press.
2	Geology and Society, Coates, D.R. (1985), Chapman & Hall, New York.
3	Environmental Geology, Keller, E.A. (1999), 8thediton, Pearson.
4	Geology, Environment and Society, Valdiya, K. S. (2004), Universities Press.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/105/105/105105170/
2	https://serc.carleton.edu/teachearth/teach_geo_online/index.html
3	https://www.edx.org/learn/geosciences

Course Designed By: Dr. R. Rajkumar

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	M	M	M	M	M
CO2	M	M	L	M	S	M	M	M	L	S
CO3	M	M	M	L	M	L	L	M	M	M
CO4	M	M	M	M	M	M	M	M	L	L

*S-Strong; M-Medium; L-Low

EDUCATE TO ELEVATE

Third Semester

Course code	20ENVA33A	REMOTE SENSING AND GIS	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Basic knowledge on remote sensing and geographic data	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To teach the principles and applications of spatial information technologies viz RS, GPS and GIS about the distribution of resources.
2. To give hands-on training on the uses of GIS software in environmental studies

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To learn how sensors collect spatial geographic data	
2	To generate geographical information by processing digital data by remote sensing and assess its environmental applications.	
3	To apply RS, GIS and GPS tools in various dimensions of the environment.	

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Elements of Photographic Systems and Computer Applications	14 - hours

Land stat. IRS and other satellite systems- satellite data. Principals involved in thermal IR image and microwave image interpretation. Applications of different types of images in earth Sciences, Environmental Sciences, Archaeology, Marine studies, Forestry, Soils, Hazard management etc.

Unit:2	Concepts and Foundations of Remote Sensing	14 - hours

History of remote sensing - Electro-magnetic energy – Properties and interaction with the earth. Atmospheric windows. Black, white and grey bodies, sources of EMR. Image interpretations. Aerial photo-classification based on attitude of camera lens, distortions caused due to flight irregularities, overlaps, scale, relief displacement and its effects. Photo recognition elements, Different types of photographs.

Unit:3	Introduction to GIS and GIS Software:	14 - hours

Fundamentals of GIS: Layers and features, Raster/Vector- Georeferencing and projection, Spatial data and GIS basics; Data attributes and spatial topology, Projection / Image registration, Digitization and data attributes -map data representation, GPS.

Unit:4	GIS Applications	14 - hours

Resources mapping, Inventory and monitoring natural resources, Land cover mapping, Wetland mapping – Applications to Agriculture - Water Management, Specific Applications - Infrastructure – Ground Water. GPS applications – Principles of Accuracy – Database Creation – Networking of Data.

Unit:5	**Remote Sensing Applications**	**14 - hours**
Impact Assessment – Pollution Monitoring – Water – Air –Ocean Pollution – Land Degradation – Desertification – Industry – Mining – Ground Water Modeling – Damage Assessment – Coastal and Marine applications – Future Sensors – Satellite System – ENVISAT – Megha Tropiques – TRMM – EOS Missions – Integral Earth Observation Studies – Global Change-Case studies.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Remote Sensing and GIS for Environmental Planning, Muralikrishna, I.V. (1995), Tata-McGraw Hill.
2	Environmental Monitoring: Applications of Remote Sensing and GIS, Singh, R.B. (1992), Geocartho International Centre, Honk Hong.
3	Environmental Remote Sensing from Regional and Global Scales, Foody, G.M. and Curran, P. J. (1994), 1st edition, Wiley.
4	Introduction to Environmental Remote Sensing, Barrett, E.C and Curtis, L.F. (1982), Chapman and Hall.
5	Fundamentals of Remote Sensing, Joseph, G. (2003), Universities Press (India) Ltd., Hyderguda, Hyderabad.
Reference Books	
1	Remote Sensing and image interpretation, Lilles and, T., Keifer, R. W. and Chipman, J. W. (2004), 5th edition, John Wiley and sons, New York.
2	Remote Sensing Techniques for Environmental Analysis, Estes J. E. and Senger, L.W. (1973), John Wiley and Sons, New York.
3	Remote Sensing of Environment, Lintz, J. and Simonett, D.S. (1976), Reading, Massachusetts, Addition – Wesley Publishing Co.
4	Geographic Information Systems – Spatial Modeling and Policy Evaluation, Fischer, M. M. and Nijkamp, P. (1993), Springer – Verlag.
5	Advances in Environmental Remote Sensing, Danson, F.M. and Plummer, S.E. (1995), John Wiley & Sons.
6	Space Remote Sensing Systems – An Introduction, Chen, H.S. (1985), 2nd edition, Academic Press.
7	Digital Image Processing, Pratt, W. K. (2001), John Wiley & Sons.
8	Observation of Earth and its Environment – Survey of Missions and Sensors, Herbert, K. J. (2002), Springer-Verlag.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://onlinecourses.nptel.ac.in/noc19_ce41/preview
2	https://www.classcentral.com/course/swayam-remote-sensing-and-gis-14272
3	https://www.classcentral.com/report/swayam-moocs-course-list/
4	https://www.mooc-list.com/course/introduction-urban-geo-informatics-edx

Course Designed By: Dr. A. Manimekalan

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	M	M	S	M	L	M	M	M
CO2	M	S	M	M	S	M	L	L	M	M
CO3	L	S	M	S	S	M	M	M	S	M

*S-Strong; M-Medium; L-Low

Course code	20ENVA33B	ENVIRONMENTAL ENGINEERING	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Basic knowledge about the Waste Water Treatment plants and Air pollution abatement	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To educate the students about the designing of primary, secondary and tertiary treatment systems of waste water.
2. To gain knowledge about disinfection methods, chlorine dosage and ETP for different industries
3. To educate about air pollution abatement and odour control methods

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the engineering concepts of waste water treatment	K1
2	Understand the various parameters influencing the waste water treatment	K2
3	Attempt to design a water treatment method for real time effluents	K3
4	Know the different analytical methods of waste water treatment and disinfection methods	K4
5	Gain knowledge about environment protection and operation of pollution control devices	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** – Evaluate; **K6**-Create

Unit:1	Waste Water Characters and Primary Treatment	14 - hours

Physio-chemical and biological characteristics of waste water-Preliminary treatment-bar racks and screens, grit removal-Designing of primary treatment of waste water- -flow measurement, equalization, mixing, sedimentation, flocculation, neutralization, floatation, flash mixer, clariflocculator, sedimentation tanks.

Unit:2	Secondary Treatment-Aerobic Methods	14 - hours

Designing of Secondary treatment of waste water-Types- Aerobic waste water treatment-Designing of Aeration Tanks, Diffusers, mechanical aerators, Trickling Filters, Waste Stabilization Ponds, Rotating Biological contactor (RBC), Fluidized Bed Reactor (FBR), Activated sludge process (ASP), modifications, Advanced activated sludge process (AASP), Advantages of aerobic waste water treatment.

Unit:3	Secondary Treatment –Anaerobic Methods	14 - hours

Anaerobic waste water treatment-Designing of anaerobic digester- Up flow Anaerobic Sludge Blanket Reactor (UASB), Sewage anaerobic system for WWT- Advantages of anaerobic waste water treatment, importance of microorganisms in biological treatment. Disinfection methods-chlorination-chlorine dosage, chlorine demand, and residual chlorine.

Unit:4	Tertiary Treatment	14 - hours

Designing of Tertiary waste water treatment- Need for advanced WWT- Reverse osmosis- Ion exchange method, Methods for removal of nitrogen and phosphorus- Incinerators and Multiple Evaporators. Sludge Drying Bed, regulations for the reuse and disposal of sludge- Eco-friendly Reuse of waste water.

Unit:5	**ETP and Air Pollution Abatement**	**14 - hours**

Criteria for Effluent Treatment Plant (ETP), Industrial Effluent treatment plant – Paper, food, tannery, sugar and textile industries, Air Pollution control- Designing of Settling Chamber, bio beds, Cyclones, Fabric filters, wet scrubbers and Electrostatic Precipitators.

Unit:6	**Contemporary Issues**	**2 - hours**

Expert lectures, online seminars, case studies - webinars

	Total Lecture hours	**72 - hours**

Text Book(s)

1	Wastewater Engineering: Treatment and Reuse, Metcalf and Eddy. (2003), Tata McGraw Hill Publishing Company Ltd., New Delhi.
2	Handbook of Water and Wastewater Treatment Plant Operations, Spellman, F. R. (2003), Lewis Publishers, London.

Reference Books

1	Water and Wastewater Technology, Hammer, M.J. and Hammer, Jr. M. J. (2001), Prentice Hall of India Pvt. Ltd., New Delhi.
2	Environmental Engineering: A Design Approach, Sincero, A. P. and Sincero, G. A. (1999), Prentice-Hall of India Pvt. Ltd., New Delhi.
3	Introduction to Environmental Engineering and Science, Masters, G. M. (2004), Prentice-Hall of India Pvt. Ltd., New Delhi.
4	Environmental Engineering, Peavy, H. S. (2003), Tata McGraw Hill Publishing Company Ltd., New Delhi.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://sswm.info/sites/default/files/reference_attachments/SPERLING%202007%20Wastewater%20Characteristics,%20Treatment%20and%20Disposal.pdf

Course Designed By: Dr. B. Sathya Priya

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10
CO1	M	S	S	M	M	S	L	M	L	S
CO2	M	M	M	L	L	S	M	S	M	S
CO3	M	S	S	M	L	S	M	M	L	S
CO4	L	S	M	S	L	S	S	S	L	S
CO5	L	M	S	M	M	S	M	S	M	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA33C	ENVIRONMENTAL LAW, POLICY AND AUDITING	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Fundamental knowledge on environmental law and policy	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To understand statutory and regulatory framework in India with regard to Environmental affairs
2. To understand significant development in national and international environmental laws
3. To impart knowledge about environmental auditing, regulations and policies of India and international perspectives

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand Environmental issues and response of judiciary system to environmental issues.	K1
2	To exercise his rights like right to information, and know about legal remedies available for environmental protection – national and international environmental laws	K3
3	Know about fundamental rights of human beings to live in healthy environment – Clean air, water and soil	K3
4	Plan an environmental management system for societal benefits by improving environmental performance of organizations	K4
5	To conduct on-site assessments and prepare audit reports.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	History of Environmental Policy	14 - hours

(Ancient India, Medieval India, British India, during post independent era, the seventies, eighties and nineties)- International environmental policy – environmental problems and their impact on international system, the instruments of international environmental policy – international law- soft law - (treaties, conventions and protocols) scientific cooperation - fund support, sanction, dispute settlement procedures, non state actors and international environmental policy - Transnational environmental policies – the Indus river basin, the Ganga – Brahmaputra river basin system. .

Unit:2	International Environmental Laws	14 - hours

Hazardous Wastes-Basal convention – Necessity for International Environmental Court - United Nations Environment Programme [UNEP] role on international environment laws. Land use policy for India – Urban planning. Constitutional and legislative provisions in India : Environmental protection and fundamental rights, judicial remedies and procedures – Tort law, public nuisance, the writ jurisdiction, statutory remedies, public interest litigation, class action, freedom of information and the right to know, National Green Tribunal Act 2010, Hazardous Waste Rules, 2016.

Unit:3	Indian Environmental Legislation	14 - hours

Nodal Agencies - Ministry of Environment, Forest and Climate Change, Central Pollution Control Board, Tamilnadu Pollution Control Board- The Water (prevention and control of pollution) Act of 1974, The Water Cess act of 1977, The Wildlife Act of 1972, The Air (prevention and control of pollution) act of 1981, The Public Liability Insurance act of 1991, The National Environment Tribunal Act, 1995, The National Environment Appellate Authority act, 1997, The Mines and Minerals act, 1957- The Atomic Energy Act, 1962, The Factories Act, 1948. The Environmental Protection Act, 1986, The forest conservation act 1980, The Wildlife Protection Act 1972 (2002 amendment), Plastics Waste management Rules 2015.		
Unit:4	**Environmental Auditing**	**14 - hours**
Organizations and the environment -Objectives and Scope –Types of EA – Objective based (Liability, management and functional audits); Client driven – Elements of audit process (What, who, why and how) – Environmental issues: Identification of problems.		
Unit:5	**Benefits And Costs Of Environmental Audit**	**14 - hours**
Contents of EA reports -Tools for EA (EMSs) –International standards for environment quality –ISO 14001, 19011 - EA in India – Gazette Notification, 1992- Case studies: South India Viscose rayon unit case.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Environmental law in India, Singh, G. (2005), McMillan, New Delhi.
2	Environmental law and policy in India, Diwan, S. And Rosencrany, A. (2001), Oxford University Press, New Delhi.
Reference Books	
1	Environmental Management in Practice, Nath B., Hens, L., Compton, P. and Devuyst, D. (1998), Vol I, Routledge, London and New York.
2	The ISO 14000 Handbook: The New International Environmental Management Standards, Cascio. J. (1996), McGraw Hill Professional.
3	ISO 14004 – Environmental management systems: General guidelines on principles, systems And supporting techniques (ISO 14004: 1996 (E).
4	ISO 14001: Environmental management systems: Specification with guidance for use (ISO 14001: 1996b (E)), International organization for standardization – Switzerland.
5	Pollution Control Legislations, (1999), Vol. I and II, Tamilnadu Pollution Control Board, Chennai
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.coursera.org/learn/environmental-law
2	https://onlinecourses.nptel.ac.in/noc20_lw02/preview
3	https://onlinecourses.swayam2.ac.in/cec20_ge12/preview
4	https://shodhganga.inflibnet.ac.in/bitstream/10603/145973/12/m.chapter-v%20evolution%20of%20the%20law%20relating%20to%20environmental%20p.pdf

5	https://www.soas.ac.uk/cedep-demos/000_P508_EAEMS_K3736-Demo/module/pdfs/p508_unit_01.pdf
6	https://www.iloencyclopaedia.org/part-vii-86401/environmental-policy/item/748-environmental-auditing-definition-and-methodology
Course Designed By: Dr. D. Prabha	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	M	S	L	S	M	S	L	M
CO2	S	L	M	S	L	S	S	S	M	S
CO3	S	S	M	S	S	S	S	S	M	S
CO4	M	S	S	S	M	S	S	S	M	S
CO5	S	S	S	S	M	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA33D	ENVIRONMENTAL TOXICOLOGY	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Basic knowledge on pollutants and its effects	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Understand the occurrence and route of entry of various environmental toxicants and contaminants
2. Understand their fate and impact in environment
3. Understand their impact on the life of organism

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Gain knowledge on various environmental toxicants – toxicants in food, drugs, pesticides and PPCP's etc	K2
2	Improve understanding about the negative effects of organic and inorganic toxicants on life of organisms and on environment	K2
3	Gain knowledge on the exposure routes of toxicants, toxicological test methods, and determination of toxic levels of contaminants	K2
4	Understand the importance of toxicological regulations and will be able to explain the potential fate and effects of a contaminant in the environment	K3
5	Understood the importance of animal ethics to be followed in toxicological testing methods and option for alternative test methods	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Toxicology	14 - hours

Definitions, Major classes of environmental toxicants, Origin and Nature of Toxicants in Environment. Basic Probit analysis, concepts – Toxicants – Toxicity, Acute, sub-acute, chronic, dose effect, LD 50, LC 50 and response safe limits. Dose response relationship, graphs, concentration response relationship, Safe Limits. Biological, chemical Factors that influence. Influence of route of administration abnormal response to chemicals; basis of selective toxicity; laboratory determination of toxicity of chemicals.

Unit:2	Chemical and Metal Toxicants	14 - hours

Classification of pesticides – Pest surveillance, resistance, residual effects, toxic effects of insecticides on man and mammals. Metals- Toxicity, Properties, occurrence, Production, Industrial uses, Metabolism, Physiology, Toxicology, Prophylaxis and Therapy - Aluminium, arsenic, cadmium, chromium, lead and mercury. Mutagenesis and carcinogenesis - case studies. Emerging pollutants in environment-Pharmaceuticals and personal care products.

Unit:3	Xenobiotics in Environment	14 - hours

Bioconcentrations – Volatilization – Biological and non-biological degradations, Detoxification. Chlorinated organics in environment and their fate. Short chained chlorinated hydrocarbons – Toxicity – Ecotoxicological relevants and degradation. PCB – Dioxins levels, fate, toxicity and their global distribution. Toxaphene – occurrence and degradation. Environmental risk assessments-

Biomonitoring - Bioindicators- Environmental specimen banking.		
Unit:4	**Mechanism of Toxicants**	**14 - hours**
Bioaccumulation- Bioconcentration – Biomagnifications –mechanisms in biota – Significant influence, mechanisms and Kinetics of Bioconcentration. Cellular response to chemical stress – membrane process; intracellular fate of chemicals, cell receptors, cell injury and apoptosis. Long-term impact of chemicals in aquatic organisms, soil invertebrates and Avian species		
Unit:5	**Ecotoxic Models and Testing Methods**	**14 - hours**
Biotransformation of xenobiotics – Molecular mode of action – Toxicity Testing Methods – Microbial, algal, invertebrates and alternative toxicity tests. Multimedia mass balance models – fugacity – nonfugacity models – applications of multimedia models. Future test strategies in Ecotoxicology – Legislative perspectives. Animal management in Toxicological Evaluation: Animal extrapolation; Animal ethics		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Environmental Risks and Hazards, Cutter, S.L. (1994), Prenctice - Hall of India, New Delhi
2	Hand book of Environmental Risk Assessment and Management, Callow, P. (1998), Blackwell Science, London
Reference Books	
1	Introduction to Environmental Toxicology- Landis, W. G. and Yu, M. H. (2003),3rd edition, Lewis Publishers, CRC press , NY
2	Essentials of Toxicology – Klaassen, C.D, and Watkins III, J.B. (2003), 3rd Ed., McGrew Hill
3	Environmental Impact of Chemicals: Assessment and Control, Quint, M. D., Taylor, D., Purchase, R.(1996), The Royal Society of Chemistry, Cambridge
4	Environmental Risk Assessment Reports, Benjamin, S.L. and Belluck, D.A. (2001),CRC Press.
5	Casarett and Doull's Essentials of Toxicology. Klaassen, C. and Watkins III, J. B. (2010), 2nd edition, McGraw Hill Education
6	Environmental Toxicology-Biological and Health effects of Pollutants. Yu, M.-H.,Tsunado, H. and Tsunoda, M. (2011), 3rd edition, CRC Press
7	Ecotoxicology, Schuurmann, G. and Market, G. (1998), John Wiley & Sons, Inc
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/120/108/120108002/
2	https://nptel.ac.in/courses/120/108/120108004/
Course Designed By: Dr. J. Manivannan	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	S	L	S	S	S	L	M
CO2	S	M	M	S	S	S	S	M	L	M
CO3	S	S	S	M	L	M	S	L	L	L
CO4	S	M	S	M	L	L	S	L	L	L
CO5	M	S	S	M	L	L	S	L	L	L

*S-Strong; M-Medium; L-Low

Course code	20ENVA23E	WASTE MANAGEMENT AND BIOREMEDIATION	L	T	P	C
Core/Elective/Supportive		Core	4	0	2	4
Pre-requisite		Basic Knowledge on Wastes	Syllabus Version		2020-2021	

Course Objectives

The main objectives of this course are to:

1. Impart knowledge on the management of solid and liquid wastes from municipal and industrial sources
2. Study the principles behind remedial measures for waste management, recycling of wastes
3. Understand the concept of bioremediation

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Understanding of the management of solid and liquid wastes from municipal and industrial sources.	K2
2	Apply the principles of remedial measures of recycling, reuse and recovery from the wastes.	K3
3	Understand and describe the principle and mechanistic role of microbes in the degradation of various pollutants.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Wastes	14 - hours

Classification and Quantification – Solid Waste Management and Disposal: Sources and Generation of Solid Waste – characterization, composition and classification. Hazardous Waste Management: Cyanides, Dioxins, Detergents, Plastics, Nylon and Paper. Waste Minimization approaches – Monitoring and Management strategies. Radioactive Waste: Sources, half-life of radioactive elements, modes of decay. Effects on Plants, Animal and Man. Low and High-level Radioactive Waste Management – Waste Minimization and Treatment, Radiation standards.

Unit:2	Recycling of Wastes	14 -hours

Types – sources – composition of waste – recycling of waste for Industrial, Agricultural and Domestic P urposes; Recycling of Metals, Reuse, recovery and reduction of paper and plastics; Recycling in Food Manufacturing, Beverages, Apparel, Leather, Paper, Pulp, Chemical and other industries; Fly Ash utilization. Waste Disposal Methods –incineration, pyrolysis, medical waste disposal strategies. Strategies for conversion of biodegradable waste into organic fertilizers and fuels. Composting, Vermicomposting and biomethanization.

Unit:3	Microbial Activity and Geomicrobiology	14 - hours

Microbial Activity in Soil, Lithosphere as Microbial habitat, Microorganisms in rock and minerals, Mineral soil and Organic soil. Physiological groups of prokaryotes, Geomicrobial transformations – Biodegradation of carbonates – Biomobilization of silicon, phosphate, nitrogen. Geomicrobiology of

fossil fuel, methane, peat, coal and petroleum.		
Unit:4	**Principles of Bioremediation**	**14 - hours**
Rapid growth and Metabolism- Genetic plasticity – Metabolic pathways for the degradation of xenobiotics Microbial site characterization –Microbiological methodologies – Standard biotreatability protocols -Principles and mechanisms of biodeterioration -Microbial leaching of metal ores, microbial transformation of antibiotics and steroids-Phytoremediation and plant microbe interaction in organic and inorganic polluted soils -Genetic engineering approaches .		
Unit:5	**Aerobic Bioremediation**	**14 - hours**
Bioremediation of Surface Soils: Fate and transport of contaminants in the Vadose zone – Biodegradation in soil ecosystems – Types of soil treatment systems –Bioreactors. Subsurface Aerobic Bioremediation: in situ Bioremediation – in situ Bioventing –in situ treatments of Harbour Sediments and Lagoons. Bioremediation in fresh water and marine systems: Bench and Pilot Scale studies – in situ Bioreactor treatment of sediments – in situ treatment in marine ecosystem. Anoxic/Anaerobic Bioremediation: Anoxic/Anaerobic Processes–Fermentation, Degradation of xenobiotics – Anoxic/Anaerobic bioremediation of hydrocarbons, Phenols, Chlorophenolic compounds, Polycyclic Aromatic Hydrocarbons (PAH), Heterocyclic Compounds, Cyanide, dyes, Radioactive wastes.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	Hazardous Wastes and Solid Wastes, Liu, D.H.F and Liptak, B.G. (2000), Lewis Publishers, New York.
2	Geomicrobiology, Ehrlich, H. L. (1996), Marcel Dekker Inc., New York.
3	Bioremediation, Baker, K. H. and Herson, D. S. (1994), McGraw–Hill Inc, New York
Reference Books	
1	Microbial Ecology, IV Ed., Atlast, R.M and Bartha, R, (2000), Addison Wesley Longman Inc.
2	Biodegradation and Bioremediation, Alexander, A. (1999), Academic Press
3	Recycling of Crop, Animal and Human Waste in Agriculture, Tandon, H.L.S.(1995), McGraw Hill Publishing Co.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	http://cbs.teriin.org/pdf/Waste_Management_Handbook.pdf
2	https://www.eschooltoday.com/waste-recycling/what-is-recycling.html
3	https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/geomicrobiology
4	https://www.mdeq.ms.gov/wp-content/uploads/2017/06/Bioremediation
5	https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Aerobic_Bioremediation_(Direct)/
Course Designed By: Dr. L. Arul Pragasan	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	S	S	M	S	S	M	M	M
CO2	M	S	M	S	M	S	S	M	M	S
CO3	S	M	M	S	M	S	S	S	M	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA3EC	ENVIRONMENTAL HEALTH AND INDUSTRIAL SAFETY	L	T	P	C
Core/Elective/Supportive		ELECTIVE-3a	4	0	0	4
Pre-requisite			Syllabus Version	2020-2021		

Course Objectives:

The main objectives of this course are to:

1. To introduce students to occupational hazards and to impart knowledge to handle health, Safety and Environmental issues at workplaces.
2. To know about the environmental norms and standards
3. To understand how health, safety and environment at work interact with each other

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Know about the local and global occupational health issues and their importance	K2
2	Recognize health hazards and understands relevant functions and responsibilities of a safety expert in the working environments involving hazardous wastes, chemicals and other harmful substances which can pollute the immediate environment and cause health problems for people.	K1 & K2
3	Know about the environmental norms and standards	K2
4	Recognize, assess and evaluate occupational health hazards	K3
5	Develop skills in analyzing, sensitizing and managing the community about environmental health issues	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Introduction and Concepts of Environmental Health	14 - hours

Environmental Health - World Health organization (WHO) - concepts of environmental and public health. Human-environment interaction. Exposome –food and chemical exposure - Industrial Hazards and Safety–Physical, Chemical and Biological hazards. Occupational Diseases and Occupationally induced illness - Prevention and Control. Health problems in different types of industries – construction, textile, steel and food processing, pharmaceutical, Occupational Health and Safety considerations in Wastewater Treatment Plants. Measures for Workers. Health Education Medical First-Aid and Management of Medical Emergencies. Epidemiological approaches. Ergonomics – Need, Task Analysis, Preventing Ergonomic Hazards, Ergonomics Programme. Definition and Role of Ergonomics in Designing Work Place - Work Environment - Effects of Light, Ventilation, Vibration, Noise and stress - Performance Evaluation of Man..

Unit:2	Industrial Safety Management Techniques	14 - hours

Industrial Safety Standards. Industrial Accidents and Disasters - Frequency Rate, Prevention and Control. Dispersion of Radioactive material and release of Toxic and inflammable materials. Work Study - Method of Study and Measurement. Measurement of Skills. Safety - Cost of Expenses. Principles and Functions in Safety Management. Case Study - Preparation of report on safety and remedial measures followed in Industry.

Unit:3	**Hazards Exposure Evaluation**	**14 - hours**
Sampling techniques, Personal monitoring, Biological monitoring; Threshold Limit Values (TLV), STEL; List of Industries involving Hazardous process Occupational Hazards under the First Schedule of the Factories Act,1948; Permissible Limits of certain Chemical substances in work environment under the Second Schedule of the Factories Act, 1948; Environmental health agencies of India, USA and Europe. Databases of hazardous chemicals.		
Unit:4	**Hazards Control**	**14 - hours**
Causes of Accident - Accident statistics - Accident Reporting system, Safety Audit, Accident prevention, Disaster Planning, Safety Committee, Case studies on Bhopal, Chernobyl and similar disasters - Hazards Control: Control of Hazards Substitutions, Engineering control, Administrative control, Behaviour control, integrated control, Elimination, Control, Substitution, Isolation, Personal Protective Equipment (PPE).		
Unit:5	**Occupational Safety Laws**	**14 - hours**
Occupational Safety and Health Act and Health Administration, Right to know Laws- Indian Acts – Labour Act, Factories Act, OSHA. Parameters of safety – Factors affecting the conditions of occupational and Industrial safety – Concept of safety organization and Management - Safety Regulations - Supervisors and safety department in motivation.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	A B C of Industrial Safety, Walsh, W. and Russell, L. (1984), Pitman Publishing Ltd., United Kingdom.
2	Environmental and Industrial Safety, Hommadi, A. H. (1989), I.B.B. Publication, New Delhi.
Reference Books	
1	Environmental Strategies–Hand Book, Kolluru, R. V. (1994), McGraw Hill Inc., New York.
2	Occupational Safety and Health for Technologists, Engineers and Managers, Goetsch, D.L. (1999), Prentice Hall.
3	Safety and Environmental Management, Della - Giustina, D. E. (1996), Van Nostrand Reinhold International Thomson Publishing Inc. New York.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/110/105/110105094/
2	http://safety.ucanr.edu/Safety_Notes/
3	https://mscunisza.files.wordpress.com/2017/10/lecture-note-occupational-health-and-safety-management.pdf
4	http://www.ucen.ucsb.edu/sites/www.ucen.ucsb.edu/files/safety_training_iipp.pdf
5	https://www.ncbi.nlm.nih.gov/books/NBK55873/

Course Designed By: Dr. D. Prabha and Dr. J. Manivannan

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	S	M	S	S	S	L	S
CO2	S	M	S	S	M	S	S	S	L	M
CO3	S	L	S	S	L	S	S	S	L	M
CO4	S	L	S	S	M	S	S	S	L	S
CO5	M	S	S	M	S	S	S	S	L	S

*S-Strong; M-Medium; L-Low

Course code	20ENVA3EC	ENVIRONMENTAL MANAGEMENT AND SUSTAINABLE DEVELOPMENT	L	T	P	C
Core/Elective/Supportive		Elective-3b	4	0	0	4
Pre-requisite		Basic Knowledge on Environmental Sciences	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Impart an understanding of system approaches, tools of environmental management and management of ecosystem
2. Study various risk factors associated with environmental issues
3. Understand the various risk mitigation strategies
4. Impart knowledge on sustainable development

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the importance of environmental planning in environmental management.	K2
2	Understand the importance of various tools of Environmental Management Plans like Life Cycle Assessment, Material Analysis, Environmental Impact and Risk Assessment, Environmental Audit etc.,	K2
3	Anticipate, identify and assess the environmental issues in various industrial sectors and in cooperation with federal, state, and local agencies and officials work for mitigation strategies on issues pertaining to environmental protection.	K3
4	Develop and promote the use of ecofriendly products for sustainable development.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Concept and Scope of Environmental Management	14 - hours

Environmental Management of Resources -- Water, forest, biological, mineral and agricultural; Environmental management of chemical, mining and manufacturing industries –petroleum, coal, cement, paper, fertilizer. Analysis and prediction of Environmental issues: Environmental Planning, Establishment of Health and Environmental standards, measuring Sustainable Development, Life Cycle Assessment, Material Flow Analysis, Environmental Auditing and Environmental Management Systems and Accounting for Eco-efficiency. .

Unit:2	Principles of Risk Assessment	14 - hours

Human Health Risk Assessments, Ecological Risk Assessment, Probabilistic Risk Assessments, Determination of acceptable risk based limits for Environmental chemicals and development of risk based remediation goals.

Unit:3	Risk Assessment and Environmental Management	14 - hours

The role of Risk Assessment in Environmental Management decisions: Evaluation of Human Health Risks Associated with airborne exposures to asbestos, a diagnostic human health risk assessment for a contaminated site problem and a risk based strategy for developing a corrective action, Response plan

for petroleum – contaminated sites, Risk Management and Risk Communication.		
Unit:4	**Environmental Economics and Mitigation**	**14 - hours**
Basic concepts of Environmental Economics, International Trade and its Environmental Integrity, Eco-labeling, responsible care, design for the Environment and full-cost accounting for municipal solid waste management, Waste lands and their reclamation, Desertification and its control. Soil erosion, Formation and reclamation of user, alkaline and saline soil, Terra Preta [black carbon] soil in Amazon forests for sustainability in soil; Biochars for energy production and as mitigation measures for global warming and soil rejuvenation.		
Unit:5	**Sustainable Environmental Management**	**14 - hours**
Environmental Education and Communication, Environmental Conflict Management, Sustainable development – concept, and growth of the idea, indicators of sustainability, Sustainability of Water Resources, Sustainable Management of Forests, Sustainability in Industry, Ecosystem Management: Coastal Environments, River and Inland Water Environments, Wetlands, Desert margins, Rural and Urban Environments. Current environmental issues in India – Case studies: Narmada Dam, There Dam, Almatti Dam.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**72 - hours**

Text Book(s)	
1	A Practical Guide to Understanding Management and Reviewing Environmental Risk Assessment Reports, Benjamin, S. L. and Bullock, D. A. (2001), Lewis Publishers, Washington D.C
2	Hand Book of Environmental Risk Assessment and Management, Calow, P. (1998), Blackwell-Synergy, London.
3	Environmental Management in Practice, Volume – I to III Instruments for Environmental Management, Nath, B., Hens, L., Compton, P. And Devuyst, D. (1998), Routledge, London and New York.
Reference Books	
1	Risk based analysis for Environmental Managers, Frantzen, K.A. (2001), Lewis Publishers, Washington D.C.
2	Risk Assessment in Environmental Management, Kofi, A.-D.D. (1998), John Willey and Sons, New York.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	http://cbs.teriin.org/pdf/Waste_Management_Handbook.pdf
2	https://www.eschooltoday.com/waste-recycling/what-is-recycling.html
3	https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/geomicrobiology
4	https://www.mdeq.ms.gov/wp-content/uploads/2017/06/Bioremediation
5	https://clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Aerobic_Bioremediation_(Direct)/
Course Designed By: Dr. L. Arul Pragasan	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	S	M	M	S	M	S	S	S
CO2	S	S	M	S	M	S	M	M	M	S
CO3	M	S	M	M	M	M	M	S	M	S
CO4	M	S	M	S	M	S	S	M	M	S

*S-Strong; M-Medium; L-Low

Supportive Course

Course code	20ENVGS18	ECOTOURISM	L	T	P	C
Core/Elective/Supportive		Supportive-1	2	0	0	2
Pre-requisite	Fundamental knowledge on the importance of ecotourism activities	Syllabus Version	2020-2021			

Course Objectives:

The main objectives of this course are to:

1. Impart knowledge on the fundamentals of ecotourism activities
2. Study about the concepts of ecotourism
3. Understanding the conservation of natural resources

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the role of ecotourism for sustainable development	K2
2	Have a basic understanding on the use of business framework to plan and implement sustainable tourism	K2
3	Have detailed knowledge on the Impact of Ecotourism	K2
4	Have the knowledge for creating awareness of protecting the environment as well as consider the needs of local people	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Concepts of Tourism	8- hours

Classification – Religious Tourism – Cultural Tourism – Heritage Tourism – Monumental Tourism – Adventure Tourism – Mass Tourism – Sustainable Tourism – Consumptive and Non-Consumptive Tourism. Principles of Ecotourism – Types of Ecotourism – Concepts of Ecotourism – Origin of Ecotourism – Objectives of Ecotourism – Benefits of Ecotourism – Trends affecting Ecotourism

Unit:2	Places of Interests of Ecotourism	8 - hours

Ecocircuit of the Western Ghats – Infrastructural Facilities for Ecotourism – Maintenance of Ecological Centers – Important Biosphere Reserves. Target group of Ecotourism – Ecotourism and Conservation – Study of different Ecosystem – Rain forest Ecotourism – Mountain Ecotourism – Polar, Islands and Coasts Ecotourism – Wilderness– Marine Ecosystem- Sanctuaries and National Parks - TQM of Ecotourism Resorts, Knowledge, skills, attitude and commitment of ecotourism service providers.

Unit:3	Impact of Ecotourism	8 - hours

Economic Impacts (Fiscal Impacts, Concept and Methods) – Types and Degree of Impacts from Ecotourism activities – Socio-cultural Impacts – Ecotourism related organization – Ecotourism Research-Disasters and Ecotourism-Role of ethics in ecotourism - Advantages and Disadvantages of Ecotourism- Eco-branding and Eco-labeling of Ecotourism Products - Marketing of Ecotourism, Ecotourism and Sustainable Development - Management Issues in Ecotourism,

Ecotourism-based/related employment: Scope and areas of employment.		
Unit:6	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**26 - hours**

Text Book(s)	
1	The Encyclopedia of Ecotourism, Weaver, D. B. (2001), CABI Publishing, U.K.
2	Encyclopedia of Ecotourism, Volume I, II and III, Sinha, P.C. (2003), Anmol Publications (P) Ltd., New Delhi.
3	Ecotourism and sustainable Development, Mukherjee, N. (2008), Cybetech Publications, New Delhi.
4	Global Ecotourism, Chandra, P. (2003), Kaniskha Publishers, New Delhi.
5	Ecotourism, Weaver, D. (2001), John Wiley & Sons, Milton.

Reference Books	
1	Ecotourism. An Introduction, David, F. A. (2003), Routledge, London and New York.
2	Ecotourism Impacts, Potentials and Possibilities, Wearing, S. and Neil, J. (2009), 2nd edition, Butterworth &Heinemann, Amsterdam.
3	Case studies in ecotourism, Buckley, R. (2003), CAB International, Cambridge.
4	Environmental impacts of ecotourism, Buckley, R. (2004), CAB International, Oxfordshire.
5	Facing the wild: ecotourism, conservation, and animal encounters, Bulbeck, C. (2005), Earthscan, London.
6	Tourism, ecotourism, and protected areas. Ceballos-Lascurain, H. (1996), Gland: IUCN
7	Ecotourism: Management and Assessment, Diamantis, D. (2004), London: Thomson.
8	Ecotourism: a guide for planners and managers, Lindberg, K. and Hawkins. D.E. (eds). (1993), The Ecotourism Society, North Benninton.
9	Ecotourism, Page, S.J. and Dowling, R.K. (2002), Prentice Hall, New York.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.acseduonline.com/courses/ecotourism-14/certificate-in-ecotourism-ctecotour-184.aspx
2	https://www.classcentral.com/course/edx-sustainable-tourism-society-environmental-aspects-10356
3	https://www.openlearning.com/csu/courses/introduction-to-ecotourism/

Course Designed By: Dr. R. Rajkumar

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	M	M	L	L	L	L	L
CO2	L	L	L	L	L	S	L	L	L	M
CO3	L	S	M	L	M	L	L	M	L	L
CO4	L	S	L	L	L	L	L	L	S	L

*S-Strong; M-Medium; L-Low

Course code	20ENVAS53	NATURAL DISASTER MANAGEMENT	L	T	P	C
Core/Elective/Supportive		Supportive-2	2	0	0	2
Pre-requisite		Have a basic knowledge of natural disasters and their consequences	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To impart knowledge on the management, disaster preparedness and training and mitigation strategies during the natural disasters.
2. To acquaint the Students with the concepts, terminologies and developments in the field of Disaster Management and to inform them about the prospects of a Natural Disaster Manager.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Differentiate the different types of disasters, analyses the causes and their potential impact on the natural and man-made environments.	K2
2	Educate people about the importance of preparedness in vulnerable areas.	K3
3	Will know about the various national and international agencies that play a major role in disaster management	K4
4	The knowledge gained will enable the students to volunteer themselves in disaster management programs thus helping affected community.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Natural Disasters	8 - hours

Nature and Extent and Educative – Disasters, Cyclone, Tornadoes, Avalanches, Flood, Drought, Volcanic, Earthquakes, Fire and Landslides. Forecasting and Warning System: Cyclone Disaster Education- Cyclone Safety, Earthquake and Avalanche Safety, Flood Safety and Impact on Environment.

Unit:2	Disaster Management	8 - hours

Pre-disaster Planning-Toning of Disaster – prone areas – prioritization –regulations – protection measures during disaster - Post disaster. Relief Camp Organization –Survey and Assessment. Disaster Management Cycle – Vulnerability Analysis – Warning system –Legal Aspects – case studies for disasters and management, Safety Measures – Disaster Management plans.

Unit:3	Disaster Preparedness and Training	8 - hours

Community Preparedness in Natural Disasters- Roles and responsibilities of different national and international agencies and government - NGO, Armed forces, Paramilitary forces, Community based organizations (CBO) - Army Training for Disaster Reduction –Role of team and co-ordination - Training needs – Target Groups – Local Condition. Mitigation Strategies: Disaster Mitigation – Training for emergency.

Unit:4	Contemporary Issues	2 - hours

Expert lectures, online seminars – webinars		
	Total Lecture hours	**26 - hours**
Text Book(s)		
1	Natural Disaster, Sharma, R. K. and Sharma, G. (2005), APH Publishing Corporation, New Delhi	
2	Disaster Management: A disaster Manager's Handbook, Nick, C.W. (1992), Asian Development Bank, Manila.	
3	Earthquake: A Natural Disaster, Ashutosh, G. (1994), Ashok Publishing House. New Delhi	
4	Disaster Management approaches and strategies, Singh, T. (2006). Akansha Publishing House, New Delhi.	
5	Towards Basics of Natural Disaster Reduction, Sinha, D.K. (2006), Research Book Centre, New Delhi.	
6	Disaster Planning: The Preservation of Life and Property, Foster, H. D. (1980), Springer Verlay, New York.	
7	Disaster Management, Singh, S. K., Kundu, S. C. and Singh, S. (1998), Mittal Publications, New Delhi.	
Reference Books		
1	www.GIS. Development.net	
2	www.GIS. Development.net	
3	Disaster Management, Prakash, I. (1994), Rashtra Prahari Prakasan, Gaziabad. Publishing House, New Delhi.	
4	Natural Disaster Reduction, Misra, G. K. And Mathur, G.C. (1993), Reliance	
5	www.iirs.nrsa.org	
6	http://quake.usgs.gov	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://onlinecourses.swayam2.ac.in/cec19_hs20/preview	
2	https://www.mooc-list.com/tags/disaster-management.	
Course Designed By: Dr. M. Muniasamy		

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	M	M	M	S	S	M	S
CO2	M	S	M	M	S	S	S	M	M	S
CO3	M	M	M	S	S	M	S	S	S	M
CO4	M	M	M	S	M	M	M	M	M	S

*S-Strong; M-Medium; L-Low

Course code	ENVGS03	ENVIRONMENTAL EDUCATION AND AWARENESS	L	T	P	C
Core/Elective/Supportive		Supportive-3	2	0	0	2
Pre-requisite		Basic Knowledge on the environmental issues and its related information	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To impart understanding on the environmental education and environmental awareness
2. To undertaking case studies and surveys in the field of environmental Education

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Students will be able to understand the role and importance of Environmental Education for school children.	K2
2	Through obtained the environmental awareness knowledge, students will be able to understand the eco-friendly mitigation efforts to save the sustainable nature for future generation.	K5
3.	Observe values like love for nature, respect for rights of animals, care of plants and other living beings and protection of the environment.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Environmental Education	8- hours

Concept, scope and importance of Environmental Education - Objectives of Environmental Education at secondary school level. Values and ethics related to environment, Approaches of Environmental Education, Salient features of environmental awareness through education: programs of environmental education for secondary school children - Programs of environmental education for attitude changes among the children.

Unit:2	Environmental Hazards	8 - hours

Causes and effects of environmental hazards, effect of human activities on environment - environmental pollution - global and local (Soil pollution, water pollution, air pollution, noise pollution) - Green House effect –Ozone layer depletion –acid rain, pillar melting, rise of sea level and their implications - Mitigation efforts.

Unit:3	Environmental Awareness	8 - hours

Learning to live in harmony with nature - environmental education for development, conservation of soil, water, forests, wild life, energy resources, movement to save environment, eco-friendly technology - Alternate sources of energy – Waste management - Population and environment.

Unit:4	Contemporary Issues	2 - hours

Expert lectures, online seminars– webinars

	Total Lecture hours	**26 - hours**
Text Book(s)		
1	Environmental Impact Assessment, Canter, E.W. (1977) , McGraw Hill Co., New York.	
2	Man and Nature, Fedron, E. (1980), Progress Publishers, Moscow.	
3	Concept of Ecology, Kormondy, E. (1991), Prentice Hall of India, New Delhi.	
4	Ecology, Odem, E. P. (1975), Oxford and IBH Publishing Co., New Delhi.	
5	Environmental Science, Purdom, P.W. and Anderson, S. H. (1983), Charles E. Merril Publishing Co.	
Reference Books		
1	Education for the Environmental Concerns, Implications and Practices, Saxena, A.B. (1996), Radha Publication, New Delhi.	
2	Environmental Biology, Sharma, P. D. (1993), Rastogi and Co. Meerut.	
3	Environmental Education, Gupta, V. K. (1998), New Academic Publishing House, Mai Hiran Gate, Jallandhar.	
4	The Handbook of Environmental Education, Palmer, J. and Philips, N. (1994), Routledge, London.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://www.mooc-list.com/categories/sci-environment	
2	https://swayam.gov.in/explorer?category=Environmental_Sciences	
Course Designed By: Dr. M. Muniasamy		

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	S	S	M	S	M	S	M	S
CO2	M	S	M	S	M	M	M	M	S	M
CO3	S	S	M	M	S	M	S	S	S	S

*S-Strong; M-Medium; L-Low

Value Added Course

ADD-ON COURSES

Course code	20ENVAA01	AGROFORESTRY	L	T	P	C
Core/Elective/Supportive		Value Added Course-1	2	0	0	2
Pre-requisite		Basic Knowledge on Agroforestry	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To gain insights on the concept of agroforestry as a sustainable land use activity and agroforestry intervention methods including diagnosis & design methodologies.
2. To impart knowledge on soil and water management in agroforestry including biogeochemical cycling of nutrients.
3. To impart knowledge on interactions between tree and livestock including their management, principles of crops and fodder production in agroforestry.
4. To make familiar and grow of trees and shrubs (fruit, fodder and small timber) more suitable for agroforestry.
5. To educate the role and multiple use of agroforestry system in integrated and sustainable Agroecosystem

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the need of agroforestry and the involved biophysical processes	K1
2	Gain knowledge on the role of agroforestry systems in soil fertility and nutrient cycling	K2
3	Understand the positive and negative tree-crops-soil interactions (for light, water And nutrients).	K2
4	Acquire knowledge about the familiar of environmental conservation and international conventions, in particular the Convention on Climate Change and the Convention on Biological Diversity, and how they relate to agroforestry systems.	K3
5	Understand the opportunities for employment and cash income through agroforestry systems and also understand how agroforestry innovations can make positive impact on economy and environment	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Agroforestry and Types	8 - hours

Definition, objectives and principles. Introduction and Agroforestry Research in India, Traditional Agroforestry system in India, Structural Classification of agroforestry systems: Agrisilviculture, Silvipastoral, Agrosilvipastoral, Riparian buffer strips, Wind breaks, Shelterbelts, Contour strips, Fertility plantings, Vegetative lie Hedges/Fences, Importance and benefits of agroforestry in context of climate change and hazards, carbon sequestration potential of agroforestry systems, managing component interaction in agroforestry for higher yield, enhancing adaptive capacity.

Unit:2	Ecosystem Services of Agroforestry	8 -hours

Potential species for edible oil, industrial oil and biofuel sources, agroforestry for soil conservation

and amelioration, water conservation measures of tree based agroforestry systems-pitting system, earth basins, earthen bunds, staggered trenches /water absorption trench, agroforestry and ecosystem services, food and nutrition security, agroforestry for fuel wood and fodder production, energy security and biofuel production, agroforestry based systems of animal production, Role of N_2 fixing trees in agroforestry, management of problem soil through agroforestry, waste land development through agroforestry, reclamation of mine soils, controlling seepage-canal and water storage, agroforestry interaction, effective insect and pest control.

Unit:3	**Role of Multipurpose Plants to Agroforestry**	**8 - hours**

Nutrient cycling through agroforestry, role of multipurpose trees and shrubs to agroforestry system-*Leucaena leucocephala*, *Pongamia pinnata*, *Tamarindus indica*, *Acacia nilotica*, *Pithecellobium dulce*, *Jatropha curcas*, *Ziziphus marutinana*, *Gliricidia sepium*, *Mangifera indica*, *Ailanthus excels*, *Ceiba pentandra*, *Moringa oleifera*, *Prosopis cineraria* and grasses. Home garden development through agroforestry, advantages and disadvantages and future thrust of agroforestry systems, ecosystem services and environmental benefits-clean air, clean water, pollination/seed dispersal, flood mitigation, biodiversity mitigation, livelihood security and employment opportunities, National agroforestry policy.

Unit:4	**Contemporary Issues**	**2 - hours**

Expert lectures, case studies, online seminars - webinars

	Total Lecture hours	**26 - hours**

Text Book(s)

1	Agroforestry: Principles and Practices. Dwivedi, A. P. (1992). Oxford & IBH, New Delhi.
2	Promising Agroforestry Tree Speciein India, Chaturvedi, O.P, Handa, A.K, Uthappa, A.R, Sridhar, K.B, Kumar, N, Chavan, S.B. and Rizvi, J. (2017). CAFRI, Jhansi and ICRAF, New Delhi.
3	A Practical Manual on Agroforestry, Meena, R.N.and Singh, R.(2014). Srijan Samiti Publishers, Varanasi.
4	An Introduction to Agroforestry, Nair, P. K. R. (1993). Kluwer Academic Publishers, The Netherlands.
5	Agroforestry Systems in India: Livelihood Security & Ecosystem Services, Dagar, J. C., Singh, A. K., Arunachalam, A. (2013), Springer, UK

Reference Books

1	New Vistas in Agroforestry, Nair, P. K. R, Rai, M. R, and Buck, L. E. (2004)., Kluwer Academic Publishers, The Netherlands
2	Trees and Tree Farming, Thampan, P. K. (1993). Peekay Tree Crops Development Foundation, Cochin, India.
3	Agroforestry for Soil Management, Young, A. (1997). CAB International, UK.
4	Agroforestry Opportunities for Enhancing Resilience to Climate Change in Rain fed Areas, Rao, G. R, Prabhakar, M, Venkatesh, G, Srinivas, I. and Reddy, K. S. (2018). ICAR – CRIDA, Hyderabad, India.
5	Tree Crop Interactions–A Physiological Approach, Ong, C. K. and Huxley, P. K. (1996). ICRAF, Nairobi, Kenya.
6	Agroforestry in Sustainable Agricultural Systems, Buck, L. E, Lassoie, P. L, Fernandes, E. C.

	M. (1998). CRC Publications, Florida, USA.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	World Agroforestry Center (ICRAF): www.worldagroforestrycentre.org
2	Agroforestry at FAO: www.fao.org/forestry/9469.
Course Designed By: Dr. P. Siddhuraju	

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	M	M	M	M	M	M	S	M
CO2	M	M	M	L	M	S	S	S	S	M
CO3	L	M	S	M	S	M	S	M	S	M
CO4	M	M	M	S	M	S	M	M	S	S
CO5	M	S	M	M	M	S	M	M	S	M

*S-Strong; M-Medium; L-Low

Course code		BIOFERTILIZERS AND BIOPESTICIDES	L	T	P	C
Core/Elective/Supportive		Value Added Course-2	2	0	0	2
Pre-requisite		Basic knowledge in biological sciences and microbiology	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. To impart knowledge about beneficial microbes used as biofertilizers and biopesticides and their production and application technology
2. To impart knowledge about their production and marketing
3. To provide a platform, where actual job skills could be developed among the students aiding them in self-employment

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Know about the diversity of microorganisms and their ecological services to mankind	K2
2	Distinguish the types of biofertilizers and biopesticides	K2
3	Understand importance and role of different microbes in soil fertility and crop productivity and exploit their potential for sustainable agriculture	K5
4	Synthesize biofertilizers and pesticides on a large Scale	K3
5	Design and apply for integrated nutrient management (INM) and integrated pest management (IPM) plan	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Biofertilizers	8 - hours

Status and scope - General account of the microbes used as biofertilizers Bacteria and Fungi - advantages over chemical fertilizers. Types of Biofertilizers – Nitrogen fixers – Symbiotic nitrogen fixation, free living nitrogen fixation, Associative nitrogen fixation - Phosphate solubilizers – Phosphate mobilizers –Biofertilizer for micronutrients (Potash, iron, zinc and sulphur) –Plant Growth Promoting Rhizobacteria (PGPRs)-Mycorrhizal fungi - Liquid biofertilizers - Factors influencing the efficacy of biofertilizers.

Unit:2	Biopesticides	8 - hours

Importance, scope and potential of biopesticide - Types of biopesticides –Microbial pesticides (Bacterial, fungal and viral) – Plant Incorporated Protectants – Biochemical Pesticides-Insect pest control through biomolecules and traps – Botanical Pesticides – Biotic Agents (parasitoids and predators)- PGPRs for control of soil borne diseases - Biorationals - Promising plant species for pest control - Genetically Modified Micro-Organisms for Sustainable Soil Health Management.

Unit:3	Production and Application	8 - hours

Biofertilizers - Mass Production technology: Inoculum production - Strain selection, sterilization, growth and fermentation, mass production - field application, benefits and advantages. Biofertilizer

development from households waste. Biopesticides - Mass production technology of bio-pesticides. Virulence, pathogenicity and symptoms of entomopathogenic pathogens and nematodes-Application technology Biofertilizers and Biopesticides - for seeds, soil and foliage - Storage, shelf life, quality control and marketing. - Safety testing and Registration – Global Market.		
Unit:4	**Contemporary Issues**	**2 - hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**26 - hours**

Text Book(s)	
1	Botanicals and Biopesticides - B. S. Parmar and C. Devakumar (Eds.), 1993. Westvill Publishing House, New Delhi.
2	Krishnendu Acharya, Surjit Sen, Manjula Rai, 2019. Biofertilizers and Biopesticides. Technoworld, Kolkatta
3	Somani, L. L., S. C. Bhandari, K.K. Vyas and S.N. Saxena. 1990. Biofertilizers, Scientific Publishers - Jodhpur.
Reference Books	
1	Biofertilizers and Biopesticides in Sustainable Agriculture. 2019. B. D. Kaushik, Deepak Kumar, Md. Shamim (Eds.), Apple Academic Press.
2	Subba Rao, N.S., G.S. Venkataraman and S. Kannaiyan, 1993. Biological nitrogen fixation, ICAR Pub., New Delhi.
3	Green Trends in Insect Control, Oscar Lopez & Jose G. Fernandez-Bolanos, (Eds.), 2011. Royal Soc. of Chemistry, UK.
4	Handbook of Microbial Biofertilizers. M. K. Rai. (Ed.), 2006. Food Products Press. New York.
5	Subba Rao, N. S. 1988. Biological nitrogen fixation: recent developments, Mohan Primlani for Oxford and IBH Pub. Co. (P) Ltd., India
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	http://www.amm-mcrc.org/publications/biofertilizers.pdf
2	https://www.fnca.mext.go.jp/english/bf/bfm/pdf/Biofertilizer_Manual.pdf
3	https://www.bio-fit.eu/q8/lo1-why-biofertilizers?start=4
Course Designed By: Dr.P.Siddhuraju, Dr. D. Prabha	

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	L	S	S	L	S	S	S	S	S
CO2	S	M	S	S	L	M	S	S	S	S
CO3	S	L	S	S	L	S	S	S	S	S
CO4	S	L	S	S	L	S	M	S	S	S
CO5	S	M	S	S	L	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Job Oriented Course

Course code	20ENVJO01	INDUSTRIAL ECOLOGY	L	T	P	C
Core/Elective/Supportive		Job Oriented Course-1	2	0	0	2
Pre-requisite		Knowledge in basic ecology, pollution and industry	Syllabus Version		2020-2021	

Course Objectives:

The main objectives of this course are to:

1. Give students overview knowledge of theory, analytical methodology and practical challenges in the field of industrial ecology.
2. Educate students about the new concepts of treating industrial systems analogous to achieve zero pollution status in the Industrial Vicinity

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the theory and analytical methodology in the field of industrial ecology.	K1
2	Know the principles and practical challenges in industrial ecology.	K2
3	Understand the new concepts of treating industrial systems analogous to achieve zero pollution status in the Industrial Vicinity	K4
4	Design and develop symbiotic industrial ecosystem	K4
5	Understand about the industrial product and process design:	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Principles of Industrial Metabolism	8 - hours

The astrosphere and industrial ecology, Industrial metabolism and biological analogies, material and energy flow in industrial metabolism, internalization of materials cycle, Eco-efficiency. Industrial Ecosystems - Components of the industrial ecosystem, overview of an integrated industrial ecosystem or symbiosis, designing and developing symbiotic industrial ecosystem..

Unit:2	Life cycles, Products, Processes and Facilities	8 - hours

Life Cycles: Expanding and Closing the Materials Loop, Life Cycle Assessment, Materials and Product Budgets, Consumable, Recyclable and Service Products, Sustainable Engineering and Design for Environment, End of life Management Phase - Design for Recycling - Remanufacturing, Recycling, Waste to energy, landfill disposal Remanufacturing.

Unit:3	Industrial Product and Process Design	8 - hours

The Product and Process Challenge, Conceptual Tools for Product Designers, Design of X, Product Design Teams, The Product Realization Process, The Process Life Cycle, Approach to Process Analysis, Guidelines for Process Design and Operation, Earth System Engineering and Management - Implications for Corporation

Unit:4	Contemporary Issues	2 - hours

Expert lectures, online seminars - webinars

	Total Lecture hours	**26 - hours**
Text Book(s)		
1	Graedel T (2011) Industrial Ecology and Sustainable Engineering, Prentice Hall India Learning Private Limited	
2	Industrial Ecology: Environmental Chemistry and Hazardous Wastes, Stanley E Manahan, (1999). Lewis, New York, USA.	
3	Industrial Ecology. T. E. Graedel and B. R. Allenby, (2003). Printice Hall, New Jersey, USA.	
Reference Books		
1	Li, Xiaohong, 2018. Industrial Ecology and Industry Symbiosis for Environmental Sustainability, Palgrave Pivot.	
2	Robert U. Ayres, Leslie Ayres (2002) A Handbook of Industrial Ecology,Edward Elgar Publishing	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://www.intechopen.com/books/product-lifecycle-management-terminology-and-applications/product-design-process-and-methods	
2	http://www.umich.edu/~nppcpub/resources/compendia/INDEpdfs/INDEintro.pdf	
3	http://planet.botany.uwc.ac.za/nisl/ESS/Documents/Industrial_Ecology_Overview.pdf	
Course Designed By: Dr. M. Rajkumar and Dr. D. Prabha		

Mapping with Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10
CO1	S	S	S	M	M	S	M	S	L	S
CO2	M	M	S	M	S	S	M	M	L	S
CO3	S	S	S	M	M	S	M	S	L	S
CO4	S	M	M	M	M	S	S	S	L	S
CO5	M	S	M	S	M	S	S	S	L	S

*S-Strong; M-Medium; L-Low

Course code	20ENVJO02	AIR QUALITY MONITORING	L	T	P	C
Core/Elective/Supportive	Job Oriented Course-2		2	0	0	2
Pre-requisite	Basic knowledge on Air pollutants	Syllabus Version	2020-2021			

Course Objectives:

The main objectives of this course are to:

1. Impart knowledge on the fundamentals of Air pollution
2. Understand on the urban and industry related air quality management
3. Study about the air quality monitoring system in terms of methodologies, standards and policies

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Learn about the assessment of air quality in urban and industrial environment	K1
2	Have knowledge on strategies for minimize the emission level and mitigation measures in industry	K2
3	Understand the current national standards and guidelines for air quality assessment	K2
4	Have the skill to interpret the Air Pollution Assessment	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Ambient Air Monitoring	8 - hours

Long-term assessment of pollutant levels - Air Quality Index- Air Quality Monitoring System (AQMS) - wind speed, direction, temperature, other meteorological parameters, concentration of air pollutants - SO_2, NOx, CO, O_3 and Particulate (PM10, PM 2.5 and PM1) level. WHO and national ambient air quality standards - Indian standard.

Unit:2	Urban Air Pollution	8 - hours

Assess the extent of pollution - real time monitoring- providing air pollution data to the general public -implementation of air quality goals or standards - effectiveness of urban emissions control strategies - evaluation of air quality models - air pollution health risk assessment (AP-HRA) - socioeconomic, environmental, and policy circumstances. Case study – traffic emissions.

Unit:3	Industrial Air Pollution	8 - hours

Planning for Air Quality, Risk Assessment and Pollution Control- Air Quality Standards and Emission Regulation - Statistical Tools for Air Pollution Assessment. Air pollution from small scale industry – case study of textile and food processing industry. Assessment in large scale industry – case study of fertilizer, petroleum and thermal power station.

Unit:4	Contemporary Issues	2 - hours

Expert lectures, case studies, online seminars - webinars

	Total Lecture hours	**26 - hours**
Text Book(s)		
1	Daniel Vallero. Fundamentals of Air Pollution, 5th Edition. 2014. Academic Press. Elsevier	
2	Sharma, N., Agarwal, A.K., Eastwood, P., Gupta, T., Singh, A. P. Air Pollution and Control 1st Edition. 2018. Springer	
3	Sportisse, Bruno. Fundamentals in Air Pollution. 1st Edition. 2010. Springer	
4	Susanne M. Charlesworth Colin A. Booth. Urban Pollution: Science and Management. 2018. John Wiley & Sons Ltd	
Reference Books		
1	AkulaVenkatram Nico Schulte. Urban Transportation and Air Pollution1st Edition. 2018. Elsevier	
2	Lazaridis, Mihalis. First Principles of Meteorology and Air Pollution. 1st Edition. 2011. Springer	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	WHO air pollution guidelines - https://www.who.int/health-topics/air-pollution	
Course Designed By: Dr. P.Siddhuraju, Dr.J.Manivannan, Dr. R. Rajkumar		

Mapping with Programme Outcomes										
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	S	M	S	S	S	S	S
CO2	M	M	L	M	S	M	M	M	L	S
CO3	M	M	M	L	M	L	L	M	M	M
CO4	M	M	M	M	M	M	M	M	L	L

*S-Strong; M-Medium; L-Low

Annexure

PRACTICAL - I: 20ENVA13P1

ENVIORNMENTAL CHEMISTRY, ENVIRONMENTAL POLLUTION AND INSTRUMENTAL METHODS OF ANALYSIS

1. Spectrophotometric Methods of Estimation: Fluoride, Nitrate, Phosphate, Chromate [Cr^{6+}], Hg, Pb, Cd, three pesticides, phenol.
2. Flame photometric analysis of Na, K, and Ca.
3. Sampling and analysis of SO_2, CO_2, NOX, HC
4. Determination of
   (i) SPM in ambient air by high volume sampler, (ii) water soluble suspended matter
   (iii) Water insoluble suspended matter and (iv) organic suspended matter.
5. Study on the effect of selected air pollutants on some plants
6. An air quality survey report of an area
7. Detection and estimation of noise pollution.
8. Water quality analysis: Determinations of DO, BOD, COD, TKN, TDS, TSS, turbidity, conductivity, alkalinity, acidity, nitrate, chloride, total hardness - Instrumental and wet chemical methods of analysis.
9. Estimation of sulphate by turbidimetry.
10. Physical, Chemical and Biological properties of soil: Collection, particle size analysis (silt and clay), Soil profile, water holding capacity, density, porosity, pH, conductivity, NPK, TOC.

DATA ANALYTICS AND RESEARCH METHODS

1. Collection of Data: Primary data – Secondary data – Classification and Tabulation – Diagrammatic Representation
2. Data Analysis using software: SPSS and Excel stat: Editing, Data Tabulation,
3. Analysis: Descriptive statistics – Correlation – Regression – Factor analysis – Cluster analysis – Principal Component Analysis (PCA), Graph Plotting - One way ANOVA – Two way ANOVA
4. Environmental chemicals related databases and uses.
5. Data analytics using R – Installing R and R Studio- Understanding R Features – Importing and Exporting Files – Plots and Visualization – Case Study using R

PRACTICAL - II: 20ENVA23P1

ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

1. Different types of media preparation-liquid/solid media.
2. Enumeration of microbes from water/soil sample.
3. Pure culture – Different streaking techniques.

4. Staining techniques-Simple / Gram staining for bacteria/lacto phenol cotton blue staining for fungi.
5. Membrane filters technique.
6. Bacteriological analysis of wastewater – Most Probable Number (MPN) method.
7. Screening and isolation of bio surfactant producers from soil sample.
8. Screening and isolation of industrially important enzyme producers (lipase/protease) from soil sample.
9. Industrially important enzyme (lipase/protease) production using waste substrate by bacteria.
10. Isolation of genomic DNA from plant sample
11. Isolation of genomic DNA from bacteria.
12. Isolation of Plasmid DNA from bacteria.
13. Agarose gel electrophoresis.
14. Polymerase Chain Reaction (PCR) technique.
15. Bacterial Transformation.

BIODIVERSITY AND CONSERVATION

1. Plankton community study: Phytoplankton and Zooplankton: Species identification - Diversity – density – abundance – distribution– Primary productivity
2. Aquatic insect community study: Species identification - Diversity – density – abundance – distribution
3. Fish community study: Species identification - Diversity – density – abundance – distribution
4. Amphibians community study: Species identification - Diversity – density – abundance – distribution
5. Reptiles community study: Species identification - Diversity – density – abundance – distribution
6. Bird community study: Species identification - Diversity – density – abundance – distribution
7. Mammals community study: Species identification - Diversity – density – abundance – distribution
8. Vegetation studies: Line, quadrates and belt transect methods– Species identification - Diversity – density – abundance – distribution
9. Grassland community study: Species identification - Diversity – density – abundance – distribution
10. Taxonomic identification of plants and animals using morphological and molecular techniques.

PRACTICAL - III: 20ENVA33P1
REMOTE SENSING & GEOGRAPHICAL INFORMATION

1. Importing Aerial/ Satellite image in ERDAS
2. Georeferencing and Image/Map Projection in ERDAS
3. Supervised and Unsupervised classification

GEOGRAPHICAL INFORMATION SYSTEM

I. Visual Interpretation

1. Map reading (survey of India Topo sheet)
2. Marginal Information and Extra Marginal Information
3. Relief and Cultural Features

II. Digital Interpretation

1. Importing Aerial/Satellite Imagery and Scanned Raster Image
2. Georeferencing and Co-Ordinate System
3. Map Projection (Type of Map Projection)
4. Digitization and Editing
5. Topology Creation
6. Proximity Analysis (Buffer, Distance Measures)
7. Interpolation Analysis (Kriging, IdwEtc)
8. Density Analysis (Point, Line Etc.)
9. Surface analysis: Tin Creation – Aspect – Slope - Hill Shade - View Shed - Cut and Till

ENVIRONMENTAL ENGINEERING

1. Jar test Experiment- Optimization of coagulant and dose
2. Turbidity removal by coagulation and flocculation
3. Determination of solids in waste water
4. Determination of residual chlorine
5. Determination of adsorption process using activated carbon
6. Determination of percentage of available chlorine in a disinfectant
7. Determination of temporary and permanent hardness
8. Designing and calculation of Sedimentation tank
9. Designing and calculation of Aeration tank
10. Designing and calculation of Activated Sludge Process
11. Designing and calculation of Trickling Filter
12. Designing and calculation of Disinfection process
13. Designing and calculation of Electrostatic precipitator

WASTE MANAGEMENT AND BIOREMEDIATION

1. Studying the effect of temperature/pH/salinity on microbial growth.
2. Isolation of Metal resistant Bacteria and effect of heavy metals on microbial growth
3. Isolation and characterization of hydrocarbon tolerating/degrading microbes from polluted environment
4. Assessment of P solubilisation/ammonification potential of microbes
5. Assessment of the effects of pollutants on soil enzyme activity
6. Enzyme production using agro waste (Amylase / cellulase)

7. Effect of pH/temperature on enzymes (Amylase/ cellulase) production
8. Production of biogas from different organic waste materials
9. Exercises on estimation, composition and segregation of solid waste
10. SCP production using waste water

M. Sc. Environmental Sciences

Syllabus
(With effect from 2020-21)

Program Code:

DEPARTMENT OF ENVIRONMENTAL SCIENCES
Bharathiar University
(A State University, Accredited with "A" Grade by NAAC and
13th Rank among Indian Universities by MHRD-NIRF)
Coimbatore 641 046, INDIA

QUESTION PAPER PATTERN (2020-21)
PRACTICAL COMPONENTS MAXIMUM MARKS -100

INTERNAL MARKS: 25

Major practical	10 Marks
Minor practical	5 Marks
Spotters	5 × 2 = 10 Marks
Total	25 Marks

EXTERNAL MARKS: 75

Major/Minor Practical	55 Marks
Spotters (A, B, C, D and E)	10 Marks
Record	05 Marks
Viva -Voce	05 Marks
Total	75 Marks

QUESTION PAPER PATTERN (2020-21)
CORE & ELECTIVE PAPERS

PART-A

Time: 3.00 Hrs. Marks: 75

Answer ALL questions (10 × 1 =10)

Ten Multiple choice questions each carrying one mark

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

PART-B

Answer any FIVE (5 × 2 = 10)

Seven questions out of which FIVE have to be answered

11.
12.
13.
14.
15.
16.
17.

PART-C

Answer all Questions (5 × 5 = 25)

FIVE questions with Internal Choice

18. a or b
19. a or b
20. a or b
21. a or b
22. a or b

PART-D

Answer any THREE (3 × 10 = 30)

Five questions out of which THREE have to be answered

23.
24.
25.
26.
27.

(Unit wise distribution of questions should be followed

QUESTION PAPER PATTERN (2020-21)
SUPPORTIVE PAPERS

PART-A

Time: 2.00 Hrs.

Marks: 38

Answer ALL questions (6 × 1=6)

Six Multiple choice questions each carrying one mark

1.

2.

3.

4.

5.

6.

PART-B

Answer any THREE (3 × 2 = 6)

Five questions out of which THREE have to be answered

7.

8.

9.

10

11.

PART-C

Answer ALL Questions (2 × 5 = 10)

TWO questions with Internal Choice

12. a or b

13. a or b

PART-D

Answer any TWO (2 × 8 = 16)

Three questions out of which TWO have to be answered

14.

15.

16.

(Unit wise distribution of questions should be followed)

QUESTION PAPER PATTERN (2020-21)
VALUE ADDED AND JOB ORIENTED COURSE PAPERS
(DEPARTMENT SELF EVALUATION)

PART-A

Time: 2.00 Hrs.

Marks: 38

Answer ALL Questions (6 × 1 = 6)

Six Multiple choice questions each carrying one mark

1.

2.

3.

4.

5.

6.

PART-B

Answer any THREE (3 × 2 = 6)

Five questions out of which THREE have to be answered

7.

8.

9.

10

11.

PART-C

Answer ALL Questions (2 × 5 = 10)

TWO questions with Internal Choice

12. a or b

13. a or b

PART-D

Answer any TWO (2 × 8 = 16)

Three questions out of which TWO have to be answered

14.

15.

16.

(Unit wise distribution of questions should be followed)