Syllabus under Outcome-Based Education

M.Sc. Environmental Sciences

For the Students Admitted in the Academic Year 2021-2022

Courses of study, Schemes of Examinations & Syllabi
(Choice Based Credit System)

DEPARTMENT OF ENVIRONMENTAL SCIENCES

BISHOP HEBER COLLEGE (AUTONOMOUS)

(Affiliated to Bharathidasan University
Nationally reaccredited with 'A' Grade by NAAC
Recognized by UGC as "**College of Excellence**"
"Star College" Status Awarded by the DBT
DST-FIST Sponsored College)
Tiruchirappalli – 620 017
Tamil Nadu. India

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Vision

Envisions to accomplish academic and professional excellence through holistic Environmental Science Education, ignite young minds, foster ethical attitude, nurture mutual love and compassion towards nature, and empower them to take up a promising career to create and contribute to the Nation and ultimately to environmental sustainability.

Mission

- ✓ Impart World-Class Education through Scientific and Inter-disciplinary propensity, and create passion for Environment through well-designed curriculum and dedicated teaching.
- ✓ Inculcate principles of environmental stewardship by experiential learning and instil the aptitude and attitude for cutting-edge research in multifarious fields of environment.
- ✓ Promote holistic development by fostering environmental, ethical and social values and building scientific, communicative and leadership qualities with competency to face the Global Environmental Challenges.
- ✓ Nurture self-motivated, life-long learning environmentalists and environmental entrepreneurs in partnership with academia, industry, community, governmental and non-governmental organizations for achieving sustainable development goals.

Program Outcomes

On successful completion of M.Sc. Environmental Sciences Program the post-graduate will be able to

Knowledge:

PO1: Exhibit advanced comprehensive knowledge in the field of Environmental Sciences through Inter-Disciplinary approaches

PO2: Critically analyze the relationships existing among various spheres of Natural Environment and Impact of Anthropogenic Activities

PO3: Identify and recognize appropriate scientific, research outcomes and environmental standards towards mitigation of consequences of environmental problems

Skill:

PO4: Utilize a broad spectrum of tools and techniques of qualitative and quantitative nature with the aid Computational Modeling

PO5: Assess and evaluate the results obtained from data analyses to arrive conclusions prepare the Report for dissemination

PO6: Develop multidisciplinary approaches towards designing technologies to resolve the environmental problems related but not restricted to water, wastewater treatment, air pollution, noise pollution and solid waste management strategies

Attitude:

PO7: Demonstrate leadership qualities and social responsibilities, willingness to collaborate with governmental and non-governmental agencies addressing environmental issues

PO8: Develop environmental responsibilities and disseminate environmental ethics to build a sustainable society through mass awareness programs with appropriate communication services

PO9: Infer social and professional ethics towards the development of environmental consciousness

Program Specific Outcomes

PSO1: Comprehend the principles and concepts of functioning of the environment and relate the theoretical knowledge in the field / real world with a multi-disciplinary / inter-disciplinary approach

PSO2: Determine the properties of the environment qualitatively and quantitatively and their compliance to the environmental standards and to justify the importance of Environmental Protection

PSO3: Assess the status of environment using guidelines devised by regulatory bodies towards natural resources conservation, pollution management and sustainable development

PSO4: Relate the theoretical knowledge with field applications, develop new ideas and strategies with creativity in relevant subject(s) related to Environment and contribute in various domains of the environment

Structure of the Curriculum 2021 – M.Sc. Environmental Sciences

Curricular Component	No. of Courses	Credits
Core (Theory)	11	44
Core (Practical)	05	17
Elective	05	21
Project	01	06
VLOC	01	02
Total	**23**	**90**

Core and Elective papers offered by the Department for M.Sc. Environmental Sciences Programme (2021-2023)

Sem.	Course Type	Course Code	Course Title	Hours per Week	Credits	Marks		
						CIA	ESA	Total
I	Core I	P20ES101	Environmental Meteorology	5	4	25	75	100
	Core II	P20ES102	Ecology	5	4	25	75	100
	Core III	P21ES103	Environmental Chemistry	5	4	25	75	100
	Core IV	P21ES104	Environmental Biotechnology and Toxicology	5	4	25	75	100
	Core Practical I	P20ES1P1	Field Ecology	5	4	40	60	100
	Elective I	P20ES1:1	Environmental Standards and legislation	5	4	25	75	100
II	Core V	P20ES205	Environmental Pollution	4	4	25	75	100
	Core VI	P20ES206	Research Methodology	4	4	25	75	100
	Core VII	P20ES207	Mathematical Modelling in Environmental Sciences	4	4	25	75	100
	Core Practical II	P20ES2P2	Practical in Environmental Biotechnology and Toxicology	4	4	40	60	100
	Core Practical III	P20ES2P3	Mathematical Modelling in Environmental Sciences	3	3	40	60	100
	Elective II	P20ES2:2	Biodiversity Conservation and Ecological Restoration	5	4	25	75	100
	Elective III	P20ES2:3	Energy resources	4	4	25	75	100
	VLOC	P17VL1:1/ P17VL1:2	RI / MI	2	2	25	75	100
III	Core VIII	P21ES308	Sustainable Development	5	4	25	75	100
	Core IX	P20ES309	Environmental Engineering and Pollution Control	5	4	25	75	100
	Core X	P20ES310	Environmental Impact Assessment	5	4	25	75	100
	Core XI	P20ES311	Instrumentation for Environmental Sciences	5	4	25	75	100
	Core Practical IV	P20ES3P4	Water Pollution and its Control Engineering, Soil Pollution and GIS Applications	5	4	40	60	100
	Elective IV	P202ES3:4	Remote Sensing and GIS for Environmental Sciences	5	4	25	75	100
IV	Core Practical V	P20ES4P5	Air Pollution and its control Engineering and GIS Applications	5	4	40	60	100
	Elective V	P20ES4F1	Internship and Field Work	5	4	-	-	100
	Core Project	P20ESPJ	Project- Dissertation	20	5	-	-	100
Total Credits				**90**				

Extra Credit courses offered by the Department for M.Sc. Environmental Sciences Programme

Semester	Course	Course Code	Paper Title	Credits
III	Extra Credit Course I	PXES3:1	Environmental Audit	**2**
	Extra Credit Course II	PXES3:2	Environmental Economics	**2**
	Extra Credit Course III	PXES3:3	Occupational Health and Industrial Safety	**2**
	Extra Credit Course IV	PXES3:4	Forest Management	**2**
IV	Extra Credit Course V	PXES4:1	Solid Waste Management	**2**
	Extra Credit Course VI	PXES4:2	Green Science and Technology	**2**
	Extra Credit Course VII	PXES4:3	Ecotourism	**2**

Programme Articulation Matrix – M.Sc. Environmental Sciences Programme (2021-2023)

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
P20ES101	Environmental Meteorology	H	H	M	M	L	L	M	M	L	H	L	-	M
P20ES102	Ecology	H	H	M	1	L	L	L	M	M	H	M	M	L
P21ES103	Environmental Chemistry	H	M	M	M	M	M	M	M	L	M	H	M	M
P21ES104	Environmental Biotechnology and Toxicology	H	H	M	M	L	L	L	M	M	H	L	M	M
P20ES1P1	Field Ecology	H	H	H	H	H	H	L	L	L	H	-	M	M
P20ES1:1	Environmental Standards and legislation	M	M	M	M	M	L	M	M	M	H	M	M	L
P20ES205	Environmental Pollution	H	M	M	M	M	H	M	M	M	H	M	H	M
P20ES206	Research Methodology	H	M	M	H	H	M	L	L	L	M	M	H	H
P20ES207	Mathematical Modelling in Environmental Sciences	M	M	M	H	M	M	-	-	-	M	M	M	M
P20ES2P2	Practical in Environmental Biotechnology and Toxicology	H	H	L	L	L	L	L	L	L	H	L	L	M
P20ES2P3	Mathematical Modelling in Environmental Sciences	H	H	H	H	H	H	M	M	L	H	L	H	H
P20ES2:1	Biodiversity Conservation and Ecological Restoration	H	H	L	M	M	M	H	L	L	M	M	M	M
P20ES2:2	Energy resources	H	H	M	L	L	L	L	L	L	H	M	M	L
P21ES308	Sustainable Development	M	M	M	M	M	L	M	M	L	H	L	M	H
P20ES309	Environmental Engineering and Pollution Control	H	L	L	M	M	M	L	L	L	H	M	M	M
P20ES310	Environmental Impact Assessment	M	M	M	M	M	L	M	M	L	H	L	M	H
P20ES311	Instrumentation for Environmental Sciences	H	H	M	L	M	L	L	L	L	H	L	L	L
P20ES3P4	Water Pollution and its Control Engineering, Soil Pollution and GIS Applications	H	H	M	H	M	M	L	L	L	H	M	M	M
P20ES3:1	Remote Sensing and GIS for Environmental Sciences	H	M	H	M	M	H	-	L	-	H	H	H	M
P20ES4P5	Air Pollution and its control Engineering and GIS Applications	H	M	L	H	H	H	M	L	L	H	M	M	M
PXES3:1	Environmental Audit	H	M	M	M	M	L	M	M	L	H	L	M	L
PXES3:2	Environmental Economics	H	M	M	M	M	M	M	M	L	H	M	M	M
PXES3:3	Occupational Health and Industrial Safety	H	M	M	M	M	M	M	M	L	H	M	M	M
PXES3:4	Forest Management	H	H	M	L	L	L	L	L	L	H	M	M	L
PXES4:1	Solid Waste Management	L	L	M	M	M	M	M	L	L	L	M	M	M
PXES4:2	Green Science and Technology	H	M	H	L	M	H	H	H	M	H	H	H	H
PXES4:3	Ecotourism	H	H	M	M	L	L	L	L	L	H	L	M	L

L: Low; M-Medium; H-High

Core I: ENVIRONMENTAL METEOROLOGY

Semester: I **Code: P20ES101**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Explain about atmosphere, hydrosphere, lithosphere and biosphere and establish the significance of their interrelationships	**K4**	**I**
CO2	Relate the weather with atmospheric pressure and winds and atmospheric circulation	**K4**	**II**
CO3	Illustrate the interrelationships between Atmosphere and Hydrosphere and appreciate harmony existing between each other.	**K5**	**III**
CO4	Interpret the importance of atmosphere and its processes in determining weather and climate.	**K5**	**III**
CO5	Examine the teleconnections of Southern Oscillation phenomena	**K2**	**IV**
CO6	Demonstrate the Climate Change Phenomenon and distinguish the natural and anthropogenic forcing mechanisms of climate change	**K4**	**V**

2.A. Syllabus

Unit I Atmosphere: (17 Hrs.)

Components of environment – atmosphere, hydrosphere, biosphere, lithosphere and their interrelationships; Atmosphere: Structure and composition of atmosphere; Vertical Stratification – Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere; Physical properties, Optical properties; Circulation - Latitudinal circulation features Longitudinal circulation features, Radiation and heat balance

Unit II Air Pressure and Winds: (19 Hrs.)

Coriolis Force; Types of Winds: Permanent, Secondary & Local Winds; Geostrophic Wind, Jet Streams & Rossby Waves; Major Jet Steams: Subtropical Jet Stream & Polar Jet Stream; Fronts: Types of Fronts: Stationary Front, Warm Front, Cold Front & Occluded Front. Circulation pattern of the atmosphere-Model surface circulation, actual surface circulation, Secondary surface circulation, circulation of the upper atmosphere

Unit III Interaction of Atmosphere and Hydrosphere: (13 Hrs.)

Distribution of water, hydrologic cycle and water budget; Ocean currents–based on temperature & based on depth. Role of Ocean currents in affecting the weather and climate. Cloud and Precipitation formation; Energy and moisture transformation within weather systems

Unit IV Weather Systems: (12 Hrs.)

At low latitudes and middle and high latitudes Meteorological scales: micro scale, mesoscale, synoptic scale and global scale; Cyclogenesis - Tropical cyclone-hurricanes, cyclones, typhoons and tornadoes, subtropical cyclone, Extra tropical cyclones

Unit V Earth's Climate and Climate Change: (14 Hrs.)

Koppen climate classification system; *El Nino*; ENSO; *La Nina*; Modoki; Indian Ocean Dipole (IOD); Polar Vortex & Ozone Hole (Ozone Depletion); Madden Julian Oscillation. Climate Change: forcing mechanisms – internal variability & external climate forcing; Evidence and consequences; the climate since the Earth's formation; past and modern climate change.

B. Topics for Self-study

- **Green flash** (https://www.livescience.com/26376-green-flash.html)
- **Lighting detection** (https://www.earthnetworks.com/lightning-detection/)
- **Noctilucent clouds** (https://projectpossum.org/research/noctilucent-cloud/about-noctilucent-clouds/)
- **Snow crystals** (http://www.snowcrystals.com/science/science.html)

C. Text Books

1. Miller GT, Environmental Sciences, 10th Ed. (2004). Thomson Brooks /Cole.
2. Keller EA, Introduction to Environmental Geology 4th Ed. (2008). Pearson Prentice Hall.
3. Muller OP, Blij HJ, Williams R S, Environmental Geography (2004), Oxford University Press, USA.
4. Singh JS, Gupta SR and Singh SP, Ecology, Environmental Science and Conservation (2015). S Chand Publishing, India. ISBN: 9789383746002.
5. Strahler and Strahler, Environmental Geology, Willey and Sons, NY,1970.

D. Reference Books

1. Albert BR, Chemistry of the Environment (1978), Academic Press, New York.
2. Montgomery CW, Environmental Geology (2002). McGraw Hill Publishers, ISBN: 9780073661957.
3. Johnson DO, Netteville JT, Wood JC and James M, Chemistry and the Environment (1973). W.B. Saunders Co., Philadelphia.
4. Sawyer CN, Mc Carty PL and Perkinn GF, Chemistry for Environmental Engineering 2nd Ed. (1994). Mc Graw Hill.
5. Sharma BK and Kaur H, Environmental Chemistry (1994). Goel Publishing House, Meerut.

E. Web Links

1. https://niwa.co.nz/education-and-training/schools/students/layers#:~:text=The%20atmosphere%20is%20comprised%20of,surface%20is%20called%20the%20exosphere.
2. https://scied.ucar.edu/learning-zone/how-weather-works/global-air-atmospheric-circulation#:~:text=Air%20in%20the%20atmosphere%20moves,pattern%20called%20global%20atmospheric%20circulation.&text=This%20pattern%2C%20called%20atmospheric%20circulation,the%20equator%2C%20warm%20air%20rises.
3. https://www.nationalgeographic.org/topics/resource-library-ocean-currents/?q=&page=1&per_page=25
4. https://www.nature.com/scitable/knowledge/library/earth-s-earliest-climate-24206248/

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Level of Blooms Taxonomic Transaction
Unit I	**Atmosphere**		
1.1	Atmosphere: Components of environment – atmosphere, hydrosphere, biosphere, lithosphere and their interrelationships	Recall various components of environment	K1
		Illustrate the interrelationships among the Spheres	K2
1.2	Atmosphere: Structure and composition of atmosphere; Vertical Stratification – Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere;	Explain the Structure and vertical layers of Atmosphere & relate with height and temperature variations	K2
1.3	Physical properties, Optical properties; Circulation - Latitudinal circulation features Longitudinal circulation features, Radiation and heat balance	Relate the optical properties of atmosphere with the net radiation	K1
		Examine the association between the circulation features and radiation / heat balance	K4
Unit II	**Air Pressure and Winds**		
2.1	Air Pressure and Winds: Coriolis Force; Types of Winds: Permanent, Secondary & Local Winds; Geostrophic Wind,	Demonstrate the formation of winds and their causes and classify them at local, regional & global levels	K3
2.2	Jet Streams & Rossby Waves; Major Jet Streams: Subtropical Jet Stream & Polar Jet Stream; Fronts: Types of Fronts: Stationary Front, Warm Front, Cold Front & Occluded Front.	Explain the major Jet Streams, and Fronts	K2
2.3	Circulation pattern of the atmosphere-Model surface circulation, actual surface circulation, Secondary surface circulation, circulation of the upper atmosphere	Illustrate Atmospheric Circulation Model	K2
		Distinguish between model and the real circulation Discriminate the surface circulation from upper circulation Analyze their relationships with Climate, rainfall and precipitation	K4
Unit III	**Interaction of Atmosphere and Hydrosphere**		
3.1	Interaction of Atmosphere and Hydrosphere: Distribution of water, hydrologic cycle and water	Relate the atmospheric phenomena with hydrosphere	K3

	budget; Ocean currents–based on temperature & based on depth. Role of Ocean currents in affecting the weather and climate.	Formulate hypotheses from the concepts learned	K5
3.2	Cloud and Precipitation formation; Energy and moisture transformation within weather systems	Demonstrate the formation of Clouds and Precipitation Categorize the types of Precipitation	K2
Unit IV	**Weather Systems**		
4.1	Weather Systems: At low latitudes and middle and high latitudes Meteorological scales: micro scale, mesoscale, synoptic scale and global scale;	Classify the Weather features at various scales Relate their impact on environment	K2
4.2	Cyclogenesis - Tropical cyclone-hurricanes, cyclones, typhoons and tornadoes, subtropical cyclone, Extra tropical cyclones	Illustrate the formation of Cyclones	K2
		Compare the cyclones at different latitudes	K2
Unit V	**Earth's Climate and Climate Change**		
5.1	Earth's Climate & Climate Change: Koppen climate classification system;	Recall the Koppen Classification of Climate System	K1
5.2	*El Nino*; ENSO; *La Nina*; Modoki; Indian Ocean Dipole (IOD);	Interpret the theories of formation of *El Nino*; ENSO; *La Nina*; Modoki; Indian Ocean Dipole (IOD)	K2
5.3	Polar Vortex & Ozone Hole (Ozone Depletion); Madden Julian Oscillation.	Relate the phenomena of polar vortex with ozone depletion	K1
		Examine the causes of Madden Julian Oscillation	K4
	Climate Change: forcing mechanisms – internal variability & external climate forcing; Evidence and consequences; the climate since the Earth's formation; past and modern climate change.	Demonstrate the causes of Climate change and relating with various forcing mechanisms	K2

4. Mapping Scheme (POs, PSOs and COs)

P20ES101	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	-	-	L	-	-	-	H	L	-	M
CO2	H	H	L	-	L	L	L	-	-	H	L	-	L
CO3	H	H	H	L	L	L	-	M	L	H	L	-	M
CO4	H	H	H	M	-	L	-	-	L	H	L	-	L
CO5	M	M	L	M	-	-	-	-	L	H	L	-	-
CO6	M	H	M	H	L	-	M	M	M	H	L	-	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.S.Pricilla Prabhavathi

Core II: ECOLOGY

Semester: I **Code: P20ES102**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Describe the concept, principles and dynamics of ecosystem	K2	I
CO2	Summarize and theorize the attributes and concepts of an ecosystem	K3	II
CO3	Explain and relate the adaptabilities of the biotics	K4	III
CO4	Analyze and relate the biotic interactions	K3	IV
CO5	Execute the ecological tools in the field and analyse and interpret the data.	K4	V
CO6	Appraise and conclude the obtained ecological information	K6	V

2.A. Syllabus

Unit I Ecological Concepts (15 Hrs.)

Ecosystem and its components - Abiotic factors – climate – temperature – light – humidity – edaphic – wind; Biotic factors – herbivory, predation, competition, parasitism, diseases Structure of the ecosystem - Trophic levels, food chain and food web - Function of ecosystem, Energy flow in an ecosystem Productivity – primary and secondary, Biogeochemical cycle in an ecosystem – N, P C, O and S cycles.

Unit II Attributes of Ecosystems (15 Hrs.)

Population Ecology - Attributes of Population, Functional response, Minimum viable populations - concept and application; extinction vortices – factors, types; SLOSS affect – concept and application, Community Ecology: Characteristics of a Community, Niche - Types – Grinnellian niche, Eltonian niche, Hutchinsonian niche, Niche differentiation - types – resource partitioning, predator partitioning, conditional differentiation, Ecosystem - Ecotone – characteristics - Ecocline, Edge effect, Edge species - causes and consequences; Concepts of stability and the role of disturbance, Ecological pyramid and ecological succession – models—facilitation, tolerance, and inhibition

Unit III Ecological Adaptations & Population Interactions (15 Hrs.)

Ecological adaptations **–** Structural, physiological and behavioral, Ecological genetics of population, Ecophenes, ecotypes, eco clines, ecospecies, coenospecies; ecological equivalents Types of population interaction: inter-specific and intra-specific; positive and negative interactions, Mutualism – concept and types, Commensalism – Types – Phoresy, Inquilinism, Metabiosis

Unit IV Population Interactions (15 Hrs.)

Competition – Types, evolutionary strategies, competition exclusion principle, character displacement, Predation – prey predator concept; foraging cycle; taxonomic range; solitary versus social predation; predator adaptations; antipredator adaptations; co-evolution of prey- predator interactions – Red Queen hypothesis; role in ecosystems; Lotka-Volterra equations for prey predator relationship; Competition-predation trade-off, Parasitism - Host-parasite interactions; Parasites and parasitoids, disease, Herbivory - Plant-herbivore interactions; Herbivory and plant defenses

Unit V Ecological Tools (15 Hrs.)

Fundamental concepts of sampling methods in ecology - Sampling vegetation, sampling phytoplankton, sampling periphyton, sampling insects, sampling reptiles, sampling birds, population estimation of mammals - Direct method, Indirect count, Analysis of data; Quantitative assessment of diversity - Species area curve, species abundance distribution, Girth class distribution, Estimation of Density, Frequency, Relative Frequency, Richness,

Abundance, Evenness, IVI Diversity scales - Alpha, Beta and Gamma Diversity. Diversity indices - Simpson Index, Shannon Wiener Index, Jaccard's Similarity Index

B. Topics for Self-study

- **Biogeographic zones** (https://portals.iucn.org/library/sites/library/files/documents/OP-018.pdf)
- **Biogeographic classification of India** (https://en.wikipedia.org/wiki/Biogeographic_classification_of_India)
- **Habitat Ecology (**https://www.biologydiscussion.com/ecology/top-4-types-of-habitat-ecology/59797)
- **Ecological modelling (**https://en.wikipedia.org/wiki/Ecosystem_model)

C. Text Books

1. Clarke GL, Elements of Ecology (2003), John Wiley, London.
2. Odum E P, Fundamentals of Ecology (1971). W.B., Saunders Co, Philadelphia and London.
3. Sharma PD Ecology and Environment 13th Ed. (2019), Rastogi Publications, Meerut, India. ISBN 9789350781227

D. Reference Books

1. Singh JS, Singh SP and Gupta SR, Ecology, Environment and Resource Conservation (2006). Anamaya Publisher, New Delhi.
2. Verma PS and Agarwal VK, Environmental Biology: Principles of Ecology (2015). S Chand & Company Pvt Ltd.
3. Chapman JL and Reiss MJ, Ecology-Principles and applications (1995). Cambridge University Press.

E. Web Links

1. https://libguides.brighton.ac.uk/ecology/webresearch
2. https://projects.ncsu.edu/cals/course/fw353/Estimate.htm#:~:text=In%20practice%2C%20population%20estimates%20are,%2C%20and%20mark%2Drecapture%20methods
3. https://www.questia.com/library/science-and-technology/environmental-and-earth-sciences/ecology

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Ecological Concepts**		
1.1	Ecosystem and its components Structure of the ecosystem	Recall various components of an ecosystem	K1
1.2	Function of ecosystem, Energy flow in an ecosystem Biogeochemical cycle in an ecosystem	Illustrate the interrelationships among the components of the ecosystem	K2

Unit II	**Attributes of Ecosystems**		
2.1	Population Ecology Attributes of Population, Functional response, Minimum viable populations-concept and application; extinction vortices–factors, types; SLOSS affect–concept and application,	Summarize and theorize the population attributes of an ecosystem	K4
2.2	Community Ecology: Characteristics of a Community, Niche -Types–Grinnellian niche, Eltonian niche, Hutchinsonian niche, Niche differentiation-types–resource partitioning, predator partitioning, conditional differentiation,	Summarize and theorize the community attributes of an ecosystem	K4
2.3	Ecosystem - Ecotone – characteristics - Ecocline, Edge effect, Edge species- causes and consequences; Concepts of stability and the role of disturbance	Summarize and relate the factors affecting an ecosystem	K4
2.4	Ecological pyramid and ecological succession–models—facilitation, tolerance, and inhibition	Construct the ecological pyramids in an ecosystem and theorize the concept of ecological succession	K5
Unit III	**Ecological Adaptations & Population Interactions**		
3.1	Ecological adaptations– Structural, physiological and behavioural	Explain and relate the adaptabilities of the biotics	K2
3.2	Ecological genetics of population, Ecophenes, ecotypes, ecoclines, ecospecies, coenospecies; ecological equivalents	Explain the Ecological genetics of population	K2
3.3	Types of population interaction: inter-specific and intra-specific; positive and negative interactions,	Express the types of population interaction	K2
3.4	Mutualism– concept and types	Analyze and Relate the concept of mutualism	K4
3.5	Commensalism– Types– Phoresy, Inquilinism, Metabiosis	Relate the concept of commensalism	K4
Unit IV	**Population Interactions**		
4.1	Competition–Types, evolutionary strategies, competition exclusion principle, character displacement	Analyze and Relate the concept of competition	K4
4.2	Predation–prey-predator concept; foraging cycle; taxonomic range; solitary versus social predation; predator adaptations; antipredator adaptations; co-evolution of prey-predator interactions–Red Queen hypothesis; role in ecosystems; Lotka-Volterra equations for prey predator relationship;	Analyze and Relate the concept of predation	K4
4.3	Competition-predation trade-off, Parasitism -Host-parasite interactions; Parasites and parasitoids, disease, Herbivory - Plant-herbivore interactions; Herbivory and plant defences	Relate the concept of competition	K4

Unit V	Ecological Tools		
5.1	Fundamental concepts of sampling methods in ecology	Recall the concepts of sampling methods in ecology	K1
5.2	Sampling vegetation, sampling phytoplankton, sampling periphyton, sampling insects, sampling reptiles, sampling birds, population estimation of mammals-Direct method, Indirect count,	Execute the ecological tools in the field	K3
5.3	Analysis of data; Quantitative assessment of diversity-Species area curve, species abundance distribution, Girth class distribution, Estimation of Density, Frequency, Relative Frequency, Richness, Abundance, Evenness, IVI Diversity scales -Alpha, Beta and Gamma Diversity. Diversity indices-Simpson, Shannon Wiener Index, Jaccard's Similarity Index	Analyse, Appraise and conclude the obtained ecological information	K6

4. Mapping Scheme (POs, PSOs and COs)

P20ES102	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	L	L	L	L	M	M	H	M	M	L
CO2	H	H	L	L	L	L	L	M	M	H	M	M	L
CO3	H	H	H	L	L	L	L	M	M	H	M	M	L
CO4	H	H	H	L	L	L	L	M	M	H	M	M	L
CO5	M	M	L	L	L	L	L	M	M	H	M	M	L
CO6	M	H	M	L	L	L	L	M	M	H	M	M	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Mr.K.Jeremiah Kirubananth

Core III: ENVIRONMENTAL CHEMISTRY

Semester: I **Code: P21ES103**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On the successful completion of this course the students will be able to:

CO No.	Course Outcomes	K-level	Unit
CO1	Apply the basic concepts to prepare solutions in different concentration units used in chemical analysis.	**K4**	**I**
CO2	Categorize the importance of atmospheric industrial gases and rare gases and compare thermochemical and photochemical reactions in the atmosphere.	**K4**	**II**
CO3	Determine water quality	**K5**	**III**
CO4	Estimate physico-chemical properties of soil and evaluate the soil quality.	**K5**	**IV**
CO5	Explain various biochemical reactions involved in living organisms.	**K4**	**V**
CO6	Design green synthetic methods to improve sustainability	**K5**	**V**

2. a. Syllabus

Unit 1 Basic Concepts in Chemistry (15 Hours)

Introduction to Modern Periodic table, elements, compounds, Types of chemical bonds. Avogadro's hypothesis. Stoichiometry, Molecular weight, equivalent weight, mole concept, normality, molarity, molality, ppm (*v/v*), ppb (*v/v*), µg/m^3. Volumetric analysis –principles of acid-base titrations; Primary and secondary standard substances, calculations of concentrations of solutions using specific gravities and molecular weights. Ionic product of water, pH and pOH, buffer solutions. Solubility product, solubility of gases in water, the carbonate system

Unit 2 Chemical composition of Air (15 Hours)

Particles, ions and radicals in the atmosphere. Chemical processes for the formation of inorganic and organic particulate matter. Thermo chemical and photochemical reactions in the atmosphere. Atmospheric Gas Properties, their uses and applications. Atmospheric Industrial Gas Products-Oxygen, Nitrogen and Argon as Critical to modern life. "Rare Gases-Neon, Krypton and Xenon" from the Atmosphere as Special Gases for Special Uses. Oxygen and ozone chemistry.

Unit 3 Water Chemistry (15 Hours)

The Chemistry of Natural Waters: Gas solubility, oxidation-reduction chemistry, the pE scale, acidity/alkalinity. Physico-chemical characteristics of water, Sampling methods of water, Water quality parameters and standards: Turbidity, pH, Suspended solids, hardness, residual chlorine, sulphates, phosphates, Fluoride, Sodium, Potassium, iron and manganese, DO, BOD, COD.

Unit 4 Chemistry of the soil (15 Hours)

Physico - Chemical properties of soil: Temperature, Texture, Structure, Minerals of soil - colloids in soil; ion exchange reactions in soil. Soil pH and its effects. Chemical speciation: classification of heavy metal speciation in water. Speciation schemes of copper, lead, mercury, arsenic, selenium and chromium. Trace elements and its significance.

Unit 5 Biochemistry and Green Chemistry (15 Hours)

Biochemistry: Classification and functions of carbohydrates, proteins and lipids. Metabolism - Glycolysis, Citric acid cycle, Electron transport, Oxidative phosphorylation and regulation of ATP production. Photosynthetic pathway.

Green Chemistry: Principles of Green chemistry, Concepts of atom economy and carbon trading. Safer chemicals: green solvents, ionic liquids. Tools of green technology: Waste minimization, Zero waste technology and solvent less processes.

B. Topics for Self-study:

- **pH and Buffer in living systems** (https://youtu.be/9-R98kRa9PI)
- **Organo-Halogen compounds as Pollutants** (https://youtu.be/sJNjw09k_ms)
- **Properties of Water** (https://youtu.be/h0py6BFlFZw)
- **Isomorphic Substitution** (https://youtu.be/NMhcE5enGRk)
- **Balanced food** (https://youtu.be/fR3NxCR9z2U)

C. Text Books

1. Banerji SK, Environmental chemistry (2002). Prentice-Hall of India Private Limited, New Delhi.
2. De AK, Environmental Chemistry, 5th Ed. (2003). New Age International (P) Limited, Publishers, New Delhi, ISBN 8122414885.
3. Sharma BK and Kaur H, Environmental Chemistry (1994). Goel Publishing House, Meerut.
4. Manahan SE, Environmental Chemistry (2005). CRC Press.

D. Reference Books

1. Lehninger AL, Principles of Biochemistry (1982). CBS Publishers and Distributors. Delhi.
2. Bhatia SC, Environmental Chemistry (2002). CBS Publishers and Distributors. New Delhi.
3. Cunningham P, Cooper H, Eville G and Hepworth MT, Environmental Encyclopaedia (1999). Jaico Publishing House, Mumbai.
4. Esmarch S. Gilreath, Fundamental Concepts of Inorganic Chemistry (1958). McGraw Hill Publishers, New York.
5. Don S, Essentials of Physical Chemistry (2011). CRC Press. ISBN: 9781439896938.
6. Johnson DO, Netteville JT, Wood JC and James M, Chemistry and the Environment (1973). W.B. Saunders Co., Philadelphia.
7. Williamson SJ, Fundamentals of Air Pollution (1971). Wesley Publishing Company.

E. Web Links:

1. https://learn.careers360.com/chemistry/some-basic-concepts-in-chemistry-chapter/
2. http://www.uigi.com/air.html
3. http://www.chem1.com/acad/pdf/c3redox.pdf
4. https://byjus.com/physics/air-composition-properties/
5. https://onlinelibrary.wiley.com/doi/full/10.1002/9781119300762.wsts0025
6. https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry.html

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Basic Concepts in Chemistry**		
1.1	Introduction to Modern Periodic table, elements, compounds,	Classification of elements in periodic table	K2
1.2	Avogadro's hypothesis, Molecular weight, equivalent weight, mole concept, Normality, molarity, molality, ppm(v/v), ppb(v/v), $\mu g/m^3$	Prepare solutions in different concentration units used in chemical analysis.	K4
1.3	Volumetric analysis –principles of acid-base titrations; Primary and secondary standards - preparations, calculations of concentrations of solutions using specific gravities and molecular weights.	Explain the principle of Volumetric analysis and to determine the strengths of solutions	K3
1.4	Ionic product of water, pH and pOH, buffer solutions. Solubility product, solubility of gases in water, the carbonate system.	Determination of Ionic Product and Solubility product of water	K3
		Highlight the importance of pH and pOH Buffer solution and its types	K3
Unit II	**Chemical Composition and properties of Air**		
2.1	Particles, ions and radicals in the atmosphere - Chemical processes for formation of inorganic and organic particulate matter Thermo chemical and photochemical reactions in the atmosphere	List of Particles, ions and radicals present in the atmosphere.	K2
		Explain the process of formation of Inorganic and organic particulate matter	K3
2.2	Thermo chemical and photochemical reactions in the atmosphere	Compare thermochemical and photochemical reactions in the atmosphere.	K5
2.3	Atmospheric Gas Properties, their uses and applications.	Classify the atmospheric gas properties, their uses and applications	K4
2.4	Atmospheric Industrial Gas Products-Oxygen, Nitrogen and Argon as Critical to modern life. "Rare Gases- from the Atmosphere as Special Gases for Special Uses.	Categorise the importance of atmospheric industrial gases and rare gases	K4
2.5	Oxygen and ozone chemistry.	Distinguish the chemistry of Oxygen and Ozone.	K4

Unit III	**Water Chemistry**		
3.1	The Chemistry of Natural Waters	Solve drinking water chemistry issues	K4
3.2	Physico-chemical characteristic of water	Analyze the physico-chemical characteristics of water	K4
3.3	Water sampling- Sampling methods of water	List water sampling techniques	K4
3.4	Water quality parameters and standards:	Determine the water quality	K5
Unit IV	**Chemistry of the soil**		
4.1	Introduction & physico-chemical properties of soil- soil temperature, texture, structure, minerals of soil, colloids in soil, ion-exchange reactions in soil, soil pH and its effects	Analyze the physico-chemical characteristics of soil	K5
4.2	Introduction of Chemical speciation in water-scheme of classification	Evaluate the soil quality.	K5
4.3	Chemical speciation- speciation of copper, lead, mercury, arsenic, selenium, chromium,	Elaborate the speciation of Cu, Pb, Hg, As, Se and Cr	K6
4.4	Trace elements and its significance-molybdenum and zinc	Describe the significance of trace elements	K2
Unit V	**Biochemistry and Green Chemistry**		
5.1	Classification and functions of carbohydrates, proteins and lipids	Classify carbohydrates, proteins and lipids and the functions of nutrients	K4
5.2	Metabolism - Glycolysis, Citric acid cycle, Electron transport, Oxidative phosphorylation and regulation of ATP production. Photosynthetic pathway.	Explain the mechanism of Metabolism and various biochemical processes	K3
5.3	Concepts of atom economy and carbon trading.	Design green synthetic concepts to improve sustainability	K5
5.4	Safer chemicals – green solvents, ionic liquids.	Choose green chemicals	K4
5.5	Tools of green technology: Waste minimization, Zero waste technology and solventless processes.	Apply green technology and waste minimization in chemical processes	K4

4. Mapping Scheme (POs, PSOs and COs)

P21ES103	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	-	M	M	H	M	-	-	-	L	H	M	-
CO2	M	H	M	M	M	H	M	M	M	M	H	M	M
CO3	M	L	M	H	M	H	-	-	L	L	H	M	L
CO4	H	M	L	M	H	L	-	-	-	M	M	L	M
CO5	H	M	M	M	L	M	-	-	L	M	H	L	-
CO6	H	-	L	M	-	M	M	-	-	H	L	M	-

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Open book test; Cooperative learning report, Assignment; Journal paper review, Group Presentation, Project report, Poster preparation, Proto-type or Product Demonstration etc. (as applicable)
3. End Semester Practical Examination

Indirect

1. Course-end Survey

Course Coordinator: Dr.T.Nalini

Core IV: ENVIRONMENTAL BIOTECHNOLOGY AND TOXICOLOGY

Semester: I **Code: P21ES104**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Course Outcomes	K-level	Unit
CO1	Describe the Importance of microbes and their role in environment.	**K5**	**I**
CO2	Analyze the basic concepts of biotechnology in solving environmental issues (in treatment of wastes, bioremediation etc.).	**K4**	**II**
CO3	Choose the applications of microbial technology in solving environmental issues.	**K3**	**III**
CO4	Determine suitable industrial application for pollution-less production	**K3**	**III**
CO5	Evaluate the toxicity of different substances on humans	**K5**	**IV**
CO6	Develop and devise bioremediation method / technique for removal of toxicant and clean the environment	**K3**	**V**

2.A. Syllabus

Unit I Microbiology **(15 Hrs.)**

Microbial Diversity & Systematics: Classical and modern methods and concepts; Ultra-structure of various Microbes- Bacteria; Fungi; Algae; Virus; Etiology, Epidemiology, Evaluation, and Treatment of Coronavirus (COVID-19). Microbial Interactions and Infection; Host–Pathogen interactions; Pathogenicity and virulence; Microbes and Environment; Forest Microbiome.

Unit II Microbial Technology **(15 Hrs.)**

Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, yield constants, methods of growth estimation, stringent response. Industrial Applications: Bioprocess technology; Media Formulation; Sterilization; Thermal death kinetics; Primary and secondary metabolites; Extracellular enzymes; Bio-technologically important intracellular products.

Unit III Biotechnology **(15 Hrs.)**

Molecular Techniques in Environmental Management: Molecular probes – Bioluminescence – PCRRFLP-RAPD- Immunological techniques–Hybridization techniques, R-DNA techniques. Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE). Diagnostic testing in COVID-19: Molecular testing – rtPCR, Serology testing – Antibody test

Unit IV Toxicology **(15 Hrs.)**

Toxicants in Environment, PROBIT analysis; Toxicity - Acute, sub-acute, chronic, dose effect, LD50, LC50 and response safe limits, Dose - response relationship - graphs, Safe Limits; selective toxicity. Sources, transport, mobility, disposition and effect of Pesticidal and non-pesticidal Toxicity; heavy metals.

Unit V Bioremediation **(15 Hrs.)**

Microbial- and Phyto- remediation; Bioremediation of xenobiotic compounds: organic and inorganic compounds; Immobilized cells/enzymes. Bioreactors; Bioleaching; Biomining and Biosensors. Biotechniques for air pollution abatement and odour control.

B. Topics for Self-study:

- **Submerged Fermentation** (https://microbenotes.com/submerged-fermentation/)
- **Gene cloning** (https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/)
- **Biopharmaceuticals** (https://www.intechopen.com/books/biopharmaceuticals/introductory-chapter-biopharmaceuticals)
- **Enzyme Technology** (https://microbenotes.com/enzyme-technology)

C. Text Books

1. Michael J. Pelczar, Microbiology (2010). Tata McGraw-Hill.
2. Reed, Prescott and Dunn's Industrial Microbiology (2004) CBS Publisher and Distributor, ISBN: 9788123910017.
3. Casida LE, Industrial Microbiology (2015). New Age International, PJ Limited, Publisher.
4. Singh DP and Dwivedi SK, Environmental Microbiology and Biotechnology 1st Ed. (2004). New Age International (P) Ltd., Publishers, New Delhi.
5. Klassen CD and Watkins JBIII, Casarett and Doull's, The Basic Science of Poisons Companion Handbook, Toxicology 6th Ed (2001). McGraw-Hill, New York.

D. Reference Books

1. Crawford RL and Crawford DL, Bioremediation–Principles and applications (1996) Cambridge University Press.
2. Mitchell R, Introduction to Environmental Microbiology (1974), Prentice -Hall. Inc. Englewood Cliffs, New Jersy, USA.
3. Tortora GJ, Funke BR, Case CL, Microbiology (2014). Pearson Publishers.
4. Glazer AN and Nikaido H, Microbial Biotechnology (1995), WH Freeman and Company, New York, USA.
5. Glick BR and Pastemak JJ, Molecular Biotechnology: Principles and Applications of Recombinant DNA (1994). ASM Press. Washington, DC USA.
6. Rajendran P and Gunasekaran P, Microbial Bioremediation (2006), MJP Publishers, Chennai.
7. Ricci P and Rowe MD, Health and Environmental Risk Assessment (1985). Pergamon Press, New York.

E. Web Links

1. https://micro.magnet.fsu.edu/cells/bacteriacell.html
2. https://www.grains.k-state.edu/spirel/docs/research/heat-ipm/presentations/Thermal%20death%20kinetics.pdf
3. https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/Biomining/biomining_node_en.html
4. https://acsess.onlinelibrary.wiley.com/doi/full/10.2134/csa2017.62.1202
5. https://www.ncbi.nlm.nih.gov/books/NBK554776/

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Microbiology**		
1.1	Microbial Diversity & Systematics: Classical and modern methods and Concepts;	Define the application areas of microbiology taking part in Environmental Sciences.	K1
1.2	Ultra-structure of various Microbes.Bacteria; Fungi; Algae; Virus;	Learn the occurrence, abundance and distribution of microorganism in the environment.	K1
1.3	Etiology, Epidemiology, Evaluation, and Treatment of Coronavirus (COVID-19).	Discuss the pathophysiology of Corona Virus (COVID19)	K2
1.4	Microbial Interactions and Infection; Host–Pathogen interactions; Pathogenicity and virulence;	Define general characteristics of bacteria, fungus, alga, protists and viruses.	K1
1.5	Microbes and Environment. Forest Microbiome	Demonstrate the Microbial environment in the forest ecosystem and its application	K2
Unit II	**Microbial Technology**		
2.1	Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, yield constants, methods of growth estimation, stringent response.	Define the concepts used in microbial control. Categorize and define the techniques used at controlling microorganisms.	K4
2.2	Industrial Applications: Bioprocess technology; Media Formulation; Sterilization; Thermal death kinetics; Primary and secondary metabolites; Extracellular enzymes;	Find assimilate the concepts and specific terminology of environmental Biotechnology	K1
2.3	Bio-technologically important intracellular products.	Classify the basics and concepts of various biotechnological related terms	K2
Unit III	**Biotechnology**		
3.1	Molecular Techniques in Environmental Management:	Discuss issues related to plant nutrition, quality improvement, environmental adaptation, transgenic crops and their use in agriculture	K6
3.2	Molecular probes – Bioluminescence – PCRRFLP-RAPD-Immunological techniques– Hybridization techniques, R-DNA techniques.	Analyze and Elucidate the molecular techniques involved in gene manipulation and rDNA technology	K4
3.3	Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE).	Explain the process protocol for the, synthesis and characterization of nanoparticles	K5

3.4	Diagnostic testing in COVID-19: Molecular testing – rtPCR, Serology testing – Antibody test	Explain the principles and perform diagnosis of Corona virus	K4
Unit IV	**Toxicology**		
4.1	Toxicants in Environment, PROBIT analysis;	Find toxicants in the food material, agricultural and industrial contaminants in food utilization of food waste for value added products and solid and liquid waste management strategies at the industrial level	K1
4.2	Toxicity - Acute, sub-acute, chronic, dose effect, LD50, LC50 and response safe limits, Dose -response relationship - graphs, Safe Limits; selective toxicity.	Explain various production technologies for various industrial products where microbes are involved.	K2
4.3	Sources, transport, mobility, disposition and effect of Pesticidal and non-pesticidal Toxicity; heavy metals.	Categorize indicator and pathogen microorganisms and analysis techniques.	K4
Unit V	**Bioremediation**		
5.1	Microbial- and Phyto-remediation;	Choose the microbial application in engineering practice and solution.	K3
5.2	Bioremediation of xenobiotic compounds: organic and inorganic compounds; Immobilized cells/enzymes.	Examine the advantages and limitations of current tools for investigation of environmental microbiology	K4
5.3	Bioreactors; Bioleaching; Biomining and Biosensors.	Apply and use the properties of microorganisms, principally bacteria, to remedy problems of contamination and other environmental impacts.	K3
5.4	Biotechniques for air pollution abatement and odour control.	Describe the properties of microorganisms with potential application to processes of environmental biotechnology.	K2

4. Mapping Scheme (POs, PSOs and COs)

P21ES104	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	-	-	L	-	-	-	H	L	-	M
CO2	H	H	M	-	L	L	L	-	-	H	L	L	L
CO3	H	H	H	L	L	M	-	M	M	H	M	-	M
CO4	H	H	H	L	L	M	-	M	M	H	M	-	M
CO5	H	M	H	M	M	L	L	-	L	H	L	M	L
CO6	M	H	L	M	-	-	-	-	L	H	L	-	-

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.M.Immanuel Sagayaraj

Core Practical I: FIELD ECOLOGY

Semester: I **Code: P20ES1P1**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Identify and list some local flora and fauna	K1	I
CO2	Describe the features of local flora and fauna	K2	I & II
CO3	Quantitatively assess the plant diversity, Carbon sequestration potential and Primary productivity	K4	III
CO4	Analyse, appraise and interpret the data	K6	III
CO5	Identify, describe and relate the features and adaptations in relation to the habitat	K4	IV
CO6	Explain, analyze, document, appraise and conclude the obtained ecological information	K6	V

2.A. Syllabus

Unit I Biodiversity Assessment - Qualitative analysis (15 Hrs.)

Inventory of floral biodiversity of campus – List and selective description; Trees; Shrubs; Herbs and grasses; Vines.

Unit II Biodiversity Assessment - Qualitative analysis (15 Hrs.)

Inventory of faunal biodiversity of campus—List and selective observation and description; Butterflies; Birds; Reptiles and Mammals.

Unit III Biodiversity Assessment - Quantitative analysis (15 Hrs.)

Quantitative assessment of herbal plants - Estimation of density, frequency, frequency class, abundance, relative abundance and species richness, Importance Value Index; Biotic index – Shannon Weiner Index; Tree height, girth measurement, Carbon sequestration potential of selected trees; Primary productivity in pond ecosystem; Primary productivity of standing crop in grass land.

Unit IV Habitat Ecology (15 Hrs.)

Features and adaptations; Aquatic- Freshwater – lentic, lotic; Marine – neritic, estuarine - mangrove, intertidal, tidal flats, seagrass bed, coral bed; oceanic – pelagic, benthic; Terrestrial habitat - Tundra, Forest, Desert and mountain biomes/ major terrestrial biomes.

Unit V Ethology

Observation of selected animals' behaviour and report preparation.

C. Text Books

1. Daisy A, Butterfly of Bishop Heber College (2010). Heber Au Sable Institute of Environmental Studies, Trichy, ISBN: 9788190626798.
2. Michael P, Ecological Methods for Field and Laboratory Investigations (1984), Tata McGraw Hill. ISBN: 9780074517659.

D. Reference Books

1. Relton A, Bird of Bishop Heber College (2010). Heber Au Sable Institute of Environmental Studies, Trichy. ISBN: 9789380767000.
2. Ravindranath S and Premnath S, Biomass Studies–Field Methods for Monitoring Biomass, Centre for Environmental Education (1997). Southern Regional Cell, Bangalore. ISBN: 812411134.
3. Trivedy RK, Goel PK and Trisal CL, Practical Methods in Ecology and Environmental Science (1987). Environmental Publications, Karad.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Biodiversity Assessment-Qualitative analysis**		
1.1	Inventory of floral biodiversity of campus–List and selective description; Trees; Shrubs; Herbs and grasses; Vines.	Identify, list and describe some local flora	K1
Unit II	**Biodiversity Assessment-Qualitative analysis**		
2.1	Inventory of faunal biodiversity of campus—List and selective observation and description; Butterflies; Birds; Reptiles and Mammals	Identify, list and describe some local fauna	K1
Unit III	**Biodiversity Assessment-Quantitative analysis**		
3.1	Quantitative assessment of herbal plants-Estimation of density, frequency, frequency class, abundance, relative abundance and species richness, Importance Value Index; Biotic index – Shannon Weiner Index;	Quantitatively assess, analyse, appraise and interpret the data of the plant diversity	K6
3.2	Tree height, girth measurement, Carbon sequestration potential of selected trees;	Quantitatively assess, analyse, appraise and interpret the data of Carbon sequestration potential of trees	K6
3.3	Primary productivity in pond ecosystem; Primary productivity of standing crop in grass land.	Quantitatively assess, analyse, appraise and interpret the data of the Primary productivity	K6
Unit IV	**Habitat Ecology**		
4.1	Features and adaptations; Aquatic-Freshwater – lentic, lotic; Marine – neritic, estuarine - mangrove, intertidal, tidal flats, seagrass bed, coral bed; oceanic – pelagic, benthic;	Identify, describe and relate the features and adaptations in relation to the aquatic habitat	K4
4.2	Terrestrial habitat - Tundra, Forest, Desert and mountain biomes/ major terrestrial biomes	Identify, describe and relate the features and adaptations in relation to the terrestrial habitat	K4
Unit V	**Ethology**		
5.1	Observation of selected animals' behaviour and report preparation.	Explain, analyze, document, appraise and conclude the obtained ecological information	K6

4. Mapping Scheme (POs, PSOs and COs)

P20ES1P1	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	H	H	H	L	L	L	H	-	M	M
CO2	H	H	H	H	H	H	L	L	L	H	-	M	M
CO3	H	H	H	M	M	M	L	L	L	H	-	M	M
CO4	M	M	M	H	H	H	L	L	L	H	-	M	M
CO5	H	H	H	M	M	M	L	L	L	H	-	M	L
CO6	H	H	H	M	M	M	L	L	L	H	-	M	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Pre-semester and End-semester Examinations (ESE)
3. Reports, Observation Register, Record Note Books and Viva-voce

Indirect

1. Overall performance assessment, Discussions and co-curricular activities

Course Coordinator: Dr.A.Daisy Caroline Mary

Elective I: ENVIRONMENTAL STANDARDS AND LEGISLATION

Semester: I **Code: P20ES1:1**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of this course, the students will be able to:

CO	Outcomes	K-level	Unit
CO1	State the Environmental Laws and the significance to avail them in relevance to practical situations	**K3**	**I**
CO2	State environmental legislation and various acts	**K5**	**II**
CO3	Recognize the moral grounds of utilization of resources and protecting the earth's Environment.	**K5**	**III**
CO4	Choose suitable strategies for sustainable development	**K3**	**III**
CO5	Recall the historical roadmap towards the conservation laws.	**K5**	**IV**
CO6	Classify the constitutional milieu for industrial and Environmental safety	**K6**	**V**

2.A. Syllabus

Unit I Constitution and History of Environmental Legislation (15 Hrs.)

Constitutional amendments: Pre-Independence (1853 – 1947), Independence to Stockholm conference (1947 - 1972); Post – Stockholm to Bhopal Disaster (1972 – 1984). Historical development: Levels and principles of Environmental laws. Over view on Environmental Laws in India – Article 21, Article 48A, Article 51A (g). Fundamental Duties and Fundamental Rights.

Unit II Environmental Policies (15 Hrs.)

Regulatory framework in India for environmental protection, Environmental policy in India –National Environmental Policy 2006. National Forest Policy 1988, National Water Policy 2002. Environmental Standards – National and International Regulatory agencies – standard development in India; ambient air, water, noise standards; Industry specific standards. Drinking water standards. Latest amendments (till 2020) and judicial responses on these legislations.

Unit III Environmental Regulations (15 Hrs.)

Pollution control legislations: The Water (Prevention and Control of Pollution) Act, 1974, The Water (Prevention and Control of Pollution) Cess Act, 1977, The Air (Prevention and Control of Pollution) Act, 1981, The Environmental (Protection) Act, 1986 - The Umbrella Act. Noise pollution control rules 2000, Waste management rules – Solid waste, Hazardous waste, Bio-medical waste, E-waste. Climate change related rules. Latest amendments (till 2020) and judicial responses on these legislations.

Unit IV Conservation related laws (15 Hrs.)

Indian Forest Act, 1927, Forest conservation Act, 1980, Wild life protection Act, 1972 as amended in 1991, Coastal Zone Regulation, 1997, Biodiversity Act 2002. National Environmental Tribunal Act, 1995; National Green Tribunal Act, 2010. The Recognition of Zoo, Rules, 1992. Latest amendments (till 2020) and judicial responses on these legislations.

Unit V Industrial laws for Environmental Safety (15 Hrs.)

Indian Boilers Act, 1923, Indian Electricity Act, 2003 and Rules, Indian Explosives Act, 1984 and Rules. Petroleum Act and Rules. Gas Cylinders Rules. Calcium Carbide Rules. The Insecticides Act and Rules. Radiation Protection Rules. Hazardous Material Transportation Rules. Static and Mobile (Unfired) Pressure Vessel Rules, 1981 as amended in 2000. The Dock Workers (Safety, Health & Welfare) Act, 1996 and Rules and Regulations. The Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; The Building and other Construction Worker's Welfare Cess Act, 1996 Cess Rules,1998.

B. Topics for Self-study:

- **Environmental Justice** (https://study.com/academy/lesson/what-is-environmental-justice-definition-principles-examples-issues.html)
- **Environmental Politics** (https://ocw.mit.edu/courses/political-science/17-32-environmental-politics-and-policy-spring-2003/lecture-notes/)
- **Environmental Regulations** (http://moef.gov.in/wp-content/uploads/wssd/doc2/ch2.html)
- **Environmental Economics** (https://www.rff.org/topics/environmental-economics/)

C. Text Books

1. Diwaa P, Environmental administration and law 2nd ed. (2002). Deep and Deep Publications.
2. Saxena KD, Environmental planning, policies & programs in India (1993). Shipra Publications.
3. Jain S and Jain V, Environmental Laws in India (1986). The Lawyers home, Indore.
4. Divan S and Rosencranz A, Environmental law and policy in India: cases, materials and statutes (2002). Oxford University Press.

D. Reference Books

1. Vig NJ and Axelrod RS, The Global Environment: Institutions, Law and Policy (1999). Earth Scan, London. ISBN: 9781853836459.
2. James C, Werksman H and Roderick P, Improving compliance with International Environmental Law (2006) Earth Scan London.
3. Handl G, Declaration of the United Nations conference on the human environment (Stockholm Declaration), 1972 and the Rio Declaration on Environment and Development, 1992 (2012.). United Nations Audiovisual Library of International Law, 11.
4. Constitution of India [Referred articles from Part-III, Part-IV and Part-IV-A].
5. Leelakrishnan P, Environmental law in India, 4th ed. (2016). Lexis Nexis;
6. Holmes G, Burke G, Singh and Theodore L, Environmental Management and Technology (1993). Wiley Publications.

3. Specific Learning Outcomes

Unit	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Constitution and History of Environmental Legislation**		
1.1	Constitutional amendments: Pre-Independence (1853 – 1947), Independence to Stockholm conference (1947 - 1972); Post – Stockholm to Bhopal Disaster (1972 – 1984).	Recall the Constitution and History of Environment Legislation Constitutional Amendments, Bhopal Gas Tragedy.	K2
1.2	Historical development: Levels and principles of Environmental laws. Over view on Environmental Laws in India – Article 21, Article 48A, Article 51A (g). Fundamental Duties and Fundamental Rights.	Identify the Levels and Principles of Environmental Laws in India includes Fundamental Duties and Fundamental Rights	K3
Unit II	**Environmental Policies**		

2.1	Environmental Policies Regulatory framework in India for environmental protection, Environmental policy in India – National Environmental Policy 2006. National Forest Policy 1988, National Water Policy 2002.	Value the Environmental Policies and regulatory frame work in India for Environmental Protection and Policies of India	K5
2.2	Environmental Standards – National and International Regulatory agencies – standard development in India; ambient air, water, noise standards; Industry specific standards. Drinking water standards. Latest amendments (till 2020) and judicial responses on these legislations.	Recommend the Environmental standards with the National and International Regulatory Agencies, Standard and Latest amendments and Judicial responses on legislations.	K5
Unit III	**Environmental Regulations**		
3.1	Environmental Regulations Pollution control legislations: The Water (Prevention and Control of Pollution) Act, 1974, The Water (Prevention and Control of Pollution) Cess Act, 1977, The Air (Prevention and Control of Pollution) Act, 1981, The Environmental (Protection) Act, 1986 - The Umbrella Act. Noise pollution control rules 2000, Waste management rules – Solid waste, Hazardous waste, Bio-medical waste, E-waste. Climate change related rules. Latest amendments (till 2020) and judicial responses on these legislations.	Examine the Environment-al Regulations Pollution control legislations. Water Act, Air Act, EPA Act, Solid Waste Management Rules, Latest Amendments (2020), Climate change related rules and Judicial responses on these legislations.	K5
Unit IV	**Conservation related laws**		
4.1	Conservation related laws Indian Forest Act, 1927, Forest conservation Act, 1980, Wild life protection Act, 1972 as amended in 1991, Coastal Zone Regulation, 1997, Biodiversity Act 2002. National Environmental Tribunal Act, 1995; National Green Tribunal Act, 2010. The Recognition of Zoo, Rules, 1992. Latest amendments (till 2020) and judicial responses on these legislations.	Recommend the conservation related Laws Such as Indian Forest Act, Wildlife Protection Act, Coastal Zone Regulation Act, Biodiversity Act, National Environmental Tribunal Act, National Green Tribunal Act. The Recognition of Zoo, Rules, Latest amendments (till 2020) and judicial responses on these legislations.	K5
Unit V	**Industrial laws for Environmental Safety**		

5.1	Industrial laws for Environmental Safety Indian Boilers Act, 1923, Indian Electricity Act, 2003 and Rules, Indian Explosives Act, 1984 and Rules. Petroleum Act and Rules. Gas Cylinders Rules. Calcium Carbide Rules. The Insecticides Act and Rules. Radiation Protection Rules.	Value Industrial laws for Environmental Safety Indian Boilers Act, Indian Electricity Act, Indian Explosives Act and Rules. Petroleum Act and Rules. Gas Cylinders Rules. Calcium Carbide Rules. The Insecticides Act and Rules. Radiation Protection Rules.	K5
5.2	Hazardous Material Transportation Rules. Static and Mobile (Unfired) Pressure Vessel Rules, 1981 as amended in 2000. The Dock Workers (Safety, Health & Welfare) Act, 1996 and Rules and Regulations.	Formulate Hazardous Material Transportation Rules, Static and Mobile (Unfired) Pressure Vessel Rules, 1981 as amended in 2000. The Dock Workers (Safety, Health & Welfare) Act, 1996 and Rules and Regulations.	K6
5.3	The Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; The Building and other Construction Worker's Welfare Cess Act, 1996 Cess Rules,1998.	Prioritize the Building and other Construction Workers Act Propose any welfare for the building and other construction worker's welfare.	K6

4. Mapping Scheme (POs, PSOs and COs)

P20ES1:1	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	L	-	-	-	-	-	-	M-	-	H	M	-	L
CO2	L	-	-	H	L	-	M	L	M	H	L	M	-
CO3	H	L	-	M	-	L	-	-	-	H	-	-	L
CO4	H	L	-	M	-	L	-	-	-	H	-	-	L
CO5	H	L	L	L	M	L	-	H	-	H	M	M	L
CO6	H	H	M	L	-	L	M	-	-	H	L	-	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.A.Daisy Caroline Mary

Core V: ENVIRONMENTAL POLLUTION

Semester: II **Code: P20ES205**
Credits: 4 **Hours/Week: 4**

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Categorize various forms of pollution and contaminants of the environment	K4	I
CO2	Analyze the chemical reactions /processes taking place in the environmental pollution.	K4	II & III
CO3	Inspect the sources of various pollutants.	K4	II & IV
CO4	Assess Causes and effects of various pollutants.	K5	IV
CO5	Summarize various terminologies used in pollution assessment.	K2	V
CO6	Devise and develop mitigation measures by understanding the processes of pollution.	K3	V

2.A. Syllabus

Unit I Air Pollution (15 Hrs.)

Types of air pollutants, primary and secondary – particulate and gaseous contaminants - their sources. Dispersion of air pollutants. Mixing height/depth, lapse rates, Gaussian plume model-Introduction. Gaseous pollution control measures. Automobile pollution in India; Particulate matter pollution – PM10 and PM2.5. Impact of air pollution - vegetation, animals, human beings and materials, Acid rain formation its effects on environment, Greenhouse Effect-Global Warming Stratospheric ozone depletion. Air quality standards. Case study - Photochemical smog in London and Los Angeles; Bhopal gas disaster.

Unit II Soil Pollution (12 Hrs.)

Sources, sinks and broad classification; Properties - Physico-chemical and biological (texture, structure, inorganic and organic components). Movement and sorption mechanisms of organic and inorganic contaminants and their impacts. Sediment Pollution – Black carbon – Soil pollution control measures – Physico-chemical and Biological methods. Industrial effluents and their interactions with soil components. Soil micro-organisms and their functions - degradation of pesticides and synthetic fertilizers.

Unit III Water and Thermal Pollution (13 Hrs.)

Sources of water pollution, Classification of water pollutants - Oxygen demanding wastes, pathogens, plant nutrients, synthetic organic compounds, inorganic chemicals and mineral substances. Groundwater pollution - Sources and sinks, Purification of water by adsorption, flocculation, ion exchange and reverse osmosis methods. Alternatives of end of pipe treatments, online monitoring of industrial effluents. Water quality standards. Case Study-Minnamata Disaster, Love Canal Disaster. Thermal pollution: Sources and effects.

Unit IV Marine pollution (10 Hrs.)

Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system, Impact of marine pollution, Oil pollution - sources and effects, Control measures - coastal management. Episode - Torrey Canyon, British Petroleum - Gulf of Mexico oil spill.

Unit V Radioactive and Noise Pollution (10 Hrs.)

Radiation - types and units-sources natural and man-made, Effect of radioactive pollution and nuclear explosions. Episode - Chernobyl and Fukusima Daiichi Nuclear Disaster. Noise pollution: Sources, weighting networks, measurement of noise indices (L_{eq}, L_{10}, L_{90}, L50, L_{DN}, T_{NI}). Noise dose and Noise Pollution standards and impacts of noise pollution.

B. Topics for Self-study:

- **Air Pollution Modelling** (http://home.iitk.ac.in/~anubha/Modeling.pdf)
- **Soil Profile and layers** (https://www.ctahr.hawaii.edu/mauisoil/a_profile.aspx)
- **Case Study on Water Pollution & Marine Pollution** (https://www.who.int/water_sanitation_health/resourcesquality/wpccasestudy1.pdf)
- **Case Study on Noise Pollution** (https://blogs.ntu.edu.sg/hp3203-2018-11/2017/11/14/case-study-of-new-delhi/)

C. Text Books

1. Kannan K, Fundamentals of Environmental Pollution (1991). S. Chand and Co., Delhi.
2. Rao MN and Rao HVN, Air Pollution (1989). Tata McGraw Hill Publishing Co. Ltd., New Delhi.
3. Sharma BK and Kaur H, Soil and Noise Pollution, Water Pollution (1994). Goel Publishing House, Meerut.
4. Malhotra R, Climatology (2010). Global Vision Publishing House, New Delhi.

D. Reference Books

1. Abbasi SA, Environmental pollution and its control (1998). Cogent international, Pondicherry.
2. Kudesia VP, Air pollution (1997). Pragati publications, Meerut.
3. Manahan SE, Environmental Science and Technology: A Sustainable Approach to Green Science and Technology (2006). CRC Press Taylor & Francis Group, London.
4. Das AK, Environmental Chemistry with Green Chemistry (2010). Books and Allied (P) Ltd. Kolkata.
5. Sharma BK and Kaur H, Soil and Noise Pollution (1994). Goel Publishing House, Meerut.
6. Sharma BK and Kaur H, Water Pollution (1994). Goyal Publishing House, Meerut.
7. Bhatia HS, Environmental pollution and its control (1998). Galgotia Publications (P) Limited, Delhi.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Air Pollution**		
1.1	Air pollution – Types of air pollutants, primary and secondary– particulate and gaseous contaminants-their sources.	Recall and Relate the types of Pollutant and their sources	K1
1.2	Dispersion of air pollutants. Mixing height/depth, lapse rates, Gaussian plume model-Introduction.	Assess the level of pollutants emitted through different sources and calculate the amount of pollutants	K4
1.3	Gaseous pollution control measures	Identify the specific type of pollutants in the environment	K3
1.4	Automobile pollution in India	Estimate the effects of pollution from vehicles	K5
	Particulate matter pollution– PM_{10} and $PM_{2.5}$	Analyze the effects through separation process	K4
	Impact of air pollution-vegetation, animals, human beings and materials	Analyze and compare the effects on various environment	K4
	Acid rain formation its effects on environment	Create and develop mitigation measures	K6
1.5	Green-house Effect-Global Warming Stratospheric ozone depletion	Analyze the different sources of pollution which causes the effects	K4
1.6	Air quality standards.	Compare the local pollutants values with the National and International standards	K2
1.7	Case study-Photochemical smog in London and Los Angeles; Bhopal gas disaster.	Discuss the famous environmental disaster	K6
Unit II	**Soil Pollution**		
2.1	Soil Pollution: Sources, sinks and broad classification;	Explain the classification of soil	K2
2.2	Properties-Physico-chemical and biological (texture, structure, in organic and organic components)	Helps to analyze the soil and determine the type and properties.	K4
2.3	Movement and sorption mechanisms of organic and inorganic contaminants and their impacts. Sediment Pollution– Black carbon	Helps to assess the pollution impacts	K5

2.4	Soil pollution control measures– Physico-chemical and Biological methods.	Analyze the effects through Physical, chemical and biological process	K4
2.5	Industrial effluents and their interactions with soil components. Soil micro-organisms and their functions-degradation of pesticides and synthetic fertilizers.	Compare and analyze the soil parameters with the standard	K4
Unit III	**Water and Thermal Pollution**		
3.1	Sources of water pollution, Classification of water pollutants-Oxygen demanding wastes, pathogens, plant nutrients, synthetic organic compounds, inorganic chemicals and mineral substances.	Students can Assess the sources of water pollution	K5
		classify them according the type of waste generated	K4
3.2	Ground water pollution-Sources and sinks,	Students can Estimate the sources of water pollution	K5
3.3	Purification of water by adsorption, flocculation, ion exchange and reverse osmosis methods.	Choose appropriate methods for analysis of samples	K4 K6
3.4	Alternatives of end of pipe treatments, online monitoring of industrial effluents.	Able to develop new tools for analyzing data	K3
3.5	Water quality standards.	Compare with Indian and international standards	K4
3.6	Case Study- Minnamata Disaster, Love Canal Disaster. Thermal pollution: Sources and effects.	Helps to Analyze and give solutions	K4
Unit IV	**Marine Pollution**		
4.1	Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system	Students can Assess the sources of water pollution	K5
4.2	Impact of marine pollution, Oil pollution-sources and effects, Control measures	Students can apply the theoretical knowledge in the field	K3
4.3	Coastal management.	Helps to develop disaster	K3
4.3	Episode-Torrey Canyon, British Petroleum-Gulf of Mexico oil spill.	Helps to Analyze and give solutions	K4
Unit V	**Radioactive and Noise Pollution**		
5.1	Radiation -types and units- sources natural and man-made	Analyze the various types of pollutant	K4

5.2	Effect of radioactive pollution and nuclear explosions.	Analyze the after effect of pollutant	K4
5.3	Episode-Chernobyl and Fukushima Daiichi Nuclear Disaster.	Helps to Analyze and give solutions	K4
5.4	Noise pollution: Sources, weighting networks, measurement of noise indices (L_{eq}, L_{10}, L_{90}, L_{50}, L_{DN}, TNI).	Helps to discover noise parameters and its measurement	K4
5.5	Noise dose and Noise Pollution standards and impacts of noise pollution	Examine the effects of pollutions on human ear and surrounding	K5

4. Mapping Scheme (POs, PSOs and COs)

P20ES205	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	H	M	M	-	M	-	-	H	H	H	M
CO2	-	-	L	M	M	-	-	M	M	-	M	H	-
CO3	H	L	-	-	-	H	-	-	-	H	-	-	-
CO4	H	-	L	M	H	-	M	-	M	-	M	H	H
CO5	H	-	H	M	M	M	-	-	M	-	L	-	L
CO6	H	H	M	-	M	-	-	-	H	M	H	-	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.S.Pricilla Prabhavathi

Core VI: RESEARCH METHODOLOGY

Semester: II **Code: P20ES206**
Credits: 4 **Hours/Week: 4**

1. Course Outcomes

On completion of the course, the students will be able to:

CO	Outcomes	K-level	Unit
CO1	Express the basic principles of research methods and designs.	K2	I
CO2	Use different tools for data collection (both primary and secondary).	K3	II
CO3	Use appropriate citation methods	K3	II
CO4	Recognize the processes of sampling and handling different types of data.	K5	III
C05	Analyze the different kinds of data (qualitative and quantitative).	K3	IV
CO6	Summarize the steps, processes and tools in research processes like data collection, analysis and publishing the results.	K4	V

2.A. Syllabus

Unit I Introduction **(13 Hrs.)**

Basics of Research – Scientific thinking: Reasoning and Scientific attitude. Research - definition, purpose, types of research – basic and applied research; qualitative, quantitative; descriptive, analytical, applied, fundamental, conceptual, empirical and mixed. Essential steps in Research, Research ethics and criteria for good research. Topic selection.

Unit II Literature **(12 Hrs.)**

Need and purpose of Reviewing Literature. Review process and bibliography. Identification of sources. Research Reading, Discriminative reading, Consulting Source material, working bibliography, use of index cards and reference cards. Literature Citation methods – APA, MLA, Vancouver and Harvard. Reference Manager- Open source tools.

Unit III Research Design **(20 Hrs.)**

Defining Research Problem and Formulation of Hypothesis and testing, Experimental Designs. Concepts: Cases, Variables and its Types, Sampling: Definition, Principles, Factors determining sampling- Sampling size, Sampling accuracy and precision; Types and procedures; Population and Universe, Measurement: Meaning, Levels of Measurement: Nominal, Ordinal, Interval and Ratio.

Unit IV Research Process **(15 Hrs.)**

Steps in the process of Research, Data Collection and Measurement: Sources of Secondary data; Methods of Primary data collection– Interview Schedule and Questionnaire construction - Attitude measurement and Scales – Sampling and Sampling Designs – Pilot study and pre-testing.

Unit V Report Preparation **(15 Hrs.)**

Preparation of Synopsis. Components of final Report – Title, Abstract, Key Words, Introduction, Materials and Methods, Results, Discussion, Summary and Recommendations, Acknowledgements, Appendices, References. Presentation of Results – Tables, Figures.

B. Topics for Self-study

- **Data Collection Instrument** (https://www.gfmer.ch/SRH-Course-2013/Geneva-Workshop/pdf/Data-collection-instruments-Abawi-2014.pdf)
- **Advanced MS-EXCEL** (https://www.edureka.co/blog/advanced-excel-tutorial/)
- **Search Engine Optimization** (https://www.wordstream.com/blog/ws/2015/04/30/seo-basics)
- **Research Design** (https://in.sagepub.com/sites/default/files/upm-binaries/55588_Chapter_1_Sample_Creswell_Research_Design_4e.pdf)

C. Text Books

1. Gurumani, N. (2007) Research Methodology for Biological Sciences, MJP Publishers, Chennai. ISBN: 8180940160
2. Marczyk GR, DeMatteo D and Festinger D, Essentials of Research Design and Methodology (2005). John Wiley & Sons. ISBN: 9780471470533.
3. Kothari CR, Research Methodology: Methods and Techniques (1985). New Age Publications (Academic).

D. Reference Books

1. APHA Standard Methods for the examination of water and wastewater, 20thEdition, Washington, 1998.
2. Barnes JDJ, Denney RC, Jeffery GH and Mendham J Vogel's, Text Book of Quantitative Inorganic Analysis, 6th Edition, Pearson Education Ltd., U.K, 1999.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Basics of Research–Scientific thinking: Reasoning and Scientific attitude. Research-definition, purpose	Identify the basics of research and scientific rationale; discover the scope of research	K2
1.2	Types of research– basic and applied research; qualitative, quantitative; descriptive, analytical, applied, fundamental, conceptual, empirical and mixed.	Classify and differentiate the types of research	K2
1.3	Essential steps in Research, Research ethics and criteria for good research. Topic selection.	Demonstrate ethical aspects of research	K2
Unit II	**Literature**		
2.1	Need and purpose of Reviewing Literature. Review process and bibliography.	Choose right literature and review appropriate literatures	K2 & K3
2.2	Identification of sources. Research Reading, Discriminative reading, Consulting Source material, working bibliography, use of index cards and reference cards.	Apply different modes of literature collection with the use of specific tools	K3
2.3	Literature Citation methods – APA, MLA, Vancouver and Harvard. Reference Manager-Open source tools.	Choose right citation method using advanced citation manager tools	K3
Unit III	**Research Design**		
3.1	Defining Research Problem and Formulation of Hypothesis and testing, Experimental Designs.	Develop and evaluate a hypothesis for intended research topic	K4

3.2	Concepts: Cases, Variables and its Types, Sampling: Definition, Principles, Factors determining sampling-Sampling size, Sampling accuracy and precision;	Adapt suitable sampling techniques and determine the sample size	K5
3.3	Types and procedures; Population and Universe, Measurement: Meaning, Levels of Measurement: Nominal, Ordinal, Interval and Ratio.	Distinguish and determine the right choice of methodology, sampling population and measurements	K3
Unit IV	**Research Process**		
4.1	Steps in the process of Research, Data Collection and Measurement: Sources of Secondary data	Generalize the steps and identify the sources of data for intended research	K2
4.2	Methods of Primary data collection– Interview Schedule and Questionnaire construction	Articulate suitable tools for data collection	K3
4.3	Attitude measurement and Scales– Sampling and Sampling Designs–Pilot study and pre-testing.	Employ a pilot study and examine the tools learnt previously	K3
Unit V	**Report Preparation**		
5.1	Preparation of Synopsis. Components of final Report–Title, Abstract, Key Words, Introduction, Materials and Methods, Results, Discussion, Summary and Recommendations, Acknowledgements, Appendices, References.	Identify and outline a report for the completed research topic	K4
5.2	Presentation of Results– Tables, Figures.	Demonstrate the findings with relevant methods of presentation	K3

4. Mapping Scheme (POs, PSOs and COs)

P20ES206	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	H	-	-	-	-	-	-	L	M	H	H
CO2	-	-	M	H	H	H	-	-	-	M	H	H	-
CO3	-	-	M	H	H	H	-	-	-	M	H	H	-
CO4	-	-	M	H	L	L	-	-	-	M	M	H	L
CO5	-	H	L	H	H	L	-	-	-	L	M	H	H
CO6	-	M	M	-	-	-	L	L	L	L	M	H	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
3. Course-end Survey

Course Coordinator: Dr.A. Daisy Caroline Mary

Core VII: MATHEMATICAL MODELLING IN ENVIRONMENTAL SCIENCES

Semester: II **Code: P20ES207**

Credits: 4 **Hours/Week: 4**

1. Course Outcomes:

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1.	Examine the basic concepts of statistics and its role as an important tool in arriving at conclusions in the study of environment	**K4**	**I**
CO2.	Determine the integral and differential values using various methods	**K5**	**II**
CO3.	Identify the mathematical/Numerical applications in the natural environment.	**K3**	**I & II**
CO4.	Evaluate the hypotheses using various tests	**K5**	**III**
CO5.	Construct the mathematical models in understanding the dynamics of Ecosystems and pollution dispersion in the environment	**K6**	**IV**
CO6.	Develop the mathematical models by the existing models to suit the local conditions	**K6**	**V**

2 a. Syllabus:

Unit I Probability Distributions **(12 Hrs.)**

Binomial Distribution – Poisson Distribution – Normal Distribution.

Unit II Theory of Sampling **(12 Hrs.)**

Introduction – Advantages & disadvantages of sampling – Types of Samples – Random & Non-Random Sampling – Sampling Distributions – Need for Sampling Distributions – Sampling Techniques – z test.

Unit III Sampling Techniques **(12 Hrs.)**

t-test – Chi square Test – ANOVA.

Unit IV Differentiation **(12 Hrs.)**

Standard Results – Ordinary Differential Equations - Integration of simple types.

Unit V Modelling **(12 Hrs.)**

Ordinary Differential Equation of First Order – Basic Concept of Mathematical Modeling – Modeling in Ecology – Malthus Model, Lotka-Volterra Models in interactions among species. Simple Gaussian Dispersion Modeling of point Source of Pollution in Atmosphere, in Streams (Rivers, channels) and in divine waters – Simple problems only.

Topics for Self-Study:

- **Calculus (**https://www.edx.org/learn/calculus)
- **Probability and Statistics (**http://www.nptelvideos.in/2012/11/probability-and-statistics.html)
- **Mathematical Modeling: Analysis and Applications** (https://onlinecourses.nptel.ac.in/noc20_ma47/preview)

c. Text Books:

1. Mariappan P, Statistics for Business 1st Ed. (2019). CRC Press, Taylor & Francis Group, Boca Raton London New York. ISBN: 9781138336179.
   a. Unit – 1: Chapter 10 & 11
   b. Unit – 2: Chapter 12: 12.1, 12.6, 12.9, 12.10, 12.11, 12.12; Chapter 13: 13.8, 13.9
   c. Unit – 3: Chapter 13: 13.15, 13.16, 13.18, 13.20
2. Mariappan P, Differential Calculus–An Application
   a. Unit – 4: Chapter 2: 2.3, 2.4, 2.6
3. Mariappan P, Intergal Calculus–An Application
   a. Unit – 4: Chapter 2: 2.1, 2.2, 2.3, 2.4
4. Mariappan P, Differential Equations
   a. Unit – 5: Chapter 2: 2.1, 2.2, 2.3, 2.4.
5. Iannelli M and Pugliese A, An introduction to Mathematical Population Dynamics-Along the trail of Volterra and Lotka (2014). Springer International Publishing
   a. Unit – 5: Chapter 1, 2, 6 & 7
6. Peavy HS, Rowe D and Tchobanoglous G, Environmental Engineering (2017). McGraw Hill Education. ISBN: 9789351340263 Unit- 5

3. Specific Learning Outcomes (SLO)

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Probability Distributions**		
1.1	Binomial Distribution– Poisson Distribution– Normal Distribution	Identify the Binomial, Poisson and the normal probability distribution and apply it appropriately	K3
Unit II	**Theory of Sampling**		
2.1	Introduction – Advantages & disadvantages of sampling	Know the advantages and disadvantages of sampling	K1
2.2	Types of Samples – Random & Non-Random Sampling– Sampling Distributions– Need for Sampling Distributions	Understand the concept of sampling distribution and know how random & non-random samples are selected.	K2
2.3	Sampling Techniques – z test	Examine the sampling techniques using a z-test	K4
Unit III	**Sampling Techniques**		
3.1	t-test – Chi square Test–ANOVA	Choose an appropriate hypothesis testing tool and statistical methods	K1
Unit IV	**Differentiation**		
4.1	Standard Results	Evaluate the differential coefficient using first principle	K5
4.2	Ordinary Differential Equations	Solve the first order differential equations	K3

4.3	Integration of simple types	Apply integration techniques and solve the various types of problems	K3
Unit V	**Modelling**		
5.1	Ordinary Differential Equation of First Order	Relate the differential equations of various orders and data modelling	K2
5.2	Basic Concept of Mathematical Modelling – Modelling in Ecology–Malthus Model, Lotka-Volterra Models in interactions among species.	Construct and validate a suitable data model for an intended ecological problem	K6
5.3	Simple Gaussian Dispersion Modelling of point Source of Pollution in Atmosphere, in Streams (Rivers, channels) and in divine waters– Simple problems only	Construct and validate a suitable data model for an air pollution problem	K6

4. Mapping Scheme (POs, PSOs and COs)

P20ES207	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	-	-	-	M	H	-	-	-	H	M	L	M
CO2	H	-	M	H	L	L	-	-	-	H	M	L	L
CO3	-	H	L	-	-	M				L	M	L	H
CO4	L	M	-	H	M	M	-	-	-	L	L	L	M
CO5	-	M	-	H	L	M	-	-	-	L	L	H	M
CO6	L	M	-	M	-	H	-	-	-	H	L	M	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr. R.Gethsi Sharmila

Core Practical II:

PRACTICAL IN ENVIRONMENTALBIOTECHNOLOGYANDTOXICOLOGY

Semester: II **Code: P20ES2P2**

Credits: 4 **Hours/Week: 4**

1. Course Outcomes

On completion of this course the students will be able to:

CO	Outcomes	K-level	Experiment
CO1	Categorize and Perform the microbiological culture techniques using organisms collected from various environment.	**K4**	**1**
CO2	Apply the microbiological techniques in pollution redemption.	**K3**	**1-7**
CO3	Explain the State various biochemical tools for environmental assessment.	**K5**	**1-5**
CO4	Identify various instrumentation in biotechnological assays.	**K3**	**8**
CO5	Examine toxicological assays in determining the lethal concentrations/ doses of a toxicant.	**K4**	**8-11**
CO6	Perform statistical analyses from the laboratory experiments on toxicology.	**K5**	**12**

2.A. Syllabus

List of Experiments

1. Isolation and identification Bacteria from Water/Soil. **(8 Hrs.)**
2. Isolation and identification Fungi from Soil. **(4 Hrs.)**
3. Isolation and identification Actinomycetes from Soil. **(4 Hrs.)**
4. Staining procedures – Simple staining, Negative staining, Gram's staining, Ziehl-Leishman's staining. **(8 Hrs.)**
5. Total Coliform and Total Faecal Coliform- Complete MPN Test. **(4 Hrs.)**
6. Decolourisation Techniques using Microorganisms. **(4 Hrs.)**
7. Isolation of Genomic DNA from Microorganisms. **(4 Hrs.)**
8. Agarose Gel Electrophoresis of Genomic DNA. **(4 Hrs.)**
9. Estimation of Sugars in fish samples. **(4 Hrs.)**
10. Estimation of Proteins in fish samples. **(4 Hrs.)**
11. Estimation of Lipids in fish samples. (**(4 Hrs.)**
12. Bioassay – Acute Toxicity studies; LC50, LD50 estimation; PROBIT Analysis. **(8 Hrs.)**

C. Text Books

1. Dubey RC and Maheswari DK, Practical Microbiology (2009). S. Chand & company Ltd. New Delhi.
2. Pelczar MJ, Reid RD and Kreig N, Microbiology (1985). Tata Mc Graw Hill, McGrawHill Inc., USA.
3. Prema M, Ecological methods for field and laboratory investigations (1984). Tata Mc Graw Hill, New Delhi.

D. Reference Books

1. Jayaraman J, Laboratory manual in Biochemistry (2011). New Age International Publishers.
2. Woolley A, A Guide to Practical Toxicology: Evaluation, Prediction, and Risk (2008). 2nd Ed. CRC Press. ISBN: 9781420043143.

3. Specific Learning Outcomes

Experiment	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
1.	Isolation and identification Bacteria from Water/Soil.	Apply and enhance the skill on microbial analysis of environment.	K3
2.	Isolation and identification Fungi from Soil.	Relate the role of microbes in soil fertility, biogeochemical cycles, plant growth promotion.	K2
3.	Isolation and identification Actinomycetes from Soil.	Relate the microbial diseases related to environment.	K2
4.	Staining procedures – Simple staining, Negative staining, Gram's staining, Ziehl-Leishman's staining.	Determine and Demonstrates proficiency and use of following in isolation of cultures by various methods (Serial dilution, Pour-plate, Spread plate and Streak plate methods).	K5
5.	Total Coliform and Total Faecal Coliform- Complete MPN Test.	Classify and describe the microbial growth, their diversity and role in Biogeochemical processes, and microbial issues in environment.	K2
6.	Decolourisation Techniques using Microorganisms.	Identify different types of microbes by various staining techniques	K3
7.	Isolation of Genomic DNA from Microorganisms.	Find the techniques and Isolate DNA from various sources – microbes	K1
8.	Agarose Gel Electrophoresis of Genomic DNA.	Outline the optimal conditions essential for protein/nucleic acid separation and purification	K2
9.	Estimation of Sugars in fish samples.	Analyze the sugar (mono saccharide and poly polysaccharides) total sugar in the fish samples	K4
10.	Estimation of Proteins in fish samples.	Analyze the proteins in the fish samples	K4
11.	Estimation of Lipids in fish samples.	Analyze the Lipids in the fish samples	K4
12.	Bioassay – Acute Toxicity studies; LC50, LD50 estimation; PROBIT Analysis.	Estimate and Perform molecular level analysis and understand the genetic mechanism.	K6

4. Mapping Scheme (POs, PSOs and COs)

P20ES2P2	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	-	-	L	-	M	-	H	M	-	M
CO2	H	H	M	M	-	L	L	-	-	H	L	-	L
CO3	H	M	M	-	L	-	-	L	L	H	M	L	L
CO4	H	H	L	L	L	L	L	-	-	H	L	-	M
CO5	H	H	L	L	-	-	-	L	L	H	L	L	-
CO6	H	H	L	L	-	-	-	L	L	H	L	L	-

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Pre-semester and End-semester Examinations (ESE)
3. Reports, Observation Register, Record Note Books and Viva-voce

Indirect

1. Overall performance assessment, Discussions and co-curricular activities

Course Coordinator: Dr. M. Immanuel Sagayaraj

Core Practical III: MATHEMATICAL MODELLING IN ENVIRONMENTAL SCIENCES

Semester: II **Code: P20ES2P3**
Credits: 3 **Hours/Week: 3**

1. Course Outcomes

On completion of this course the students will be able to:

CO No.	Outcomes	K-level	Experiment
CO1	Evaluate the measures of Central tendency and dispersion for the given data in Environmental sciences using appropriate statistical tool.	**K5**	**1-2**
CO2	Discover the Lines of Regression incorporating the Correlation Coefficient	**K4**	**3-4**
CO3	Classify and compare the types of distribution	**K4**	**5-7**
CO4	Formulate the hypothesis and perform hypotheses testing using Software	**K6**	**8-12**
CO5	Examine the maximum and minimum for a given function a by applying the concept of derivatives	**K4**	**13-14**
CO6	Demonstrate mathematical models in understanding the dynamics of Ecosystems and pollution dispersion.	**K2**	**15-18**

2.A. Syllabus

List of Experiments

1. Calculation of measures of central tendency
2. Calculation of measures of dispersion
3. Calculation of Correlation Coefficient
4. Finding Lines of Regression
5. Binomial Distribution
6. Poisson Distribution
7. Normal Distribution
8. One sample t-test
9. Two sample t-test
10. Chi-square test of independent samples
11. One-way Between-Groups ANOVA
12. Two-way Between-Groups ANOVA
13. Finding differential coefficient of a function
14. Finding maximum and minimum for a given function
15. Population Model
16. Lotka – Voltera Models in species interaction;
17. Pollution dispersion model
18. Gaussian dispersion modelling in air pollution dispersion and stream water pollution dispersion

B. Topics for Self-study:

- **Data Handling – Importing CSV and tabular data files** (https://nptel.ac.in/courses/111/104/111104100/)
- **Data Handling – Importing data files from other software** (https://nptel.ac.in/courses/111/104/111104100/)
- **Data frames, import of external data in various file format** (https://nptel.ac.in/courses/111/104/111104100/)
- **Graphics and plots** (https://nptel.ac.in/courses/111/104/111104100/)

C. Text Books

1. Acevedo MF, Simulation of Ecological and Environmental Models (2013). CRC Press. *ISBN: 9781466575684.*
2. Gardener M, Beginning R – The statistical Programming Language (2015). Wiley

Publications. *ISBN*: 9781118164303.
3. Simmons GF, Differential Equations with Applications and Historical Notes 2nd Ed. (2003). McGraw Hill Publishers. *ISBN*: 9781498702591.

D. Reference Books

1 . Iannelli M and Pugliese A, An introduction to Mathematical Population Dynamics-Along the trail of Volterra and Lotka (2014). Springer International Publishing.
   a. Chapter 1, 2, 6 & 7
2. Peavy HS, Rowe D and Tchobanoglous G, Environmental Engineering (2017). McGraw Hill Education. ISBN: 9789351340263.

E. Web links

1. https://nptel.ac.in/courses/111/104/111104120/
2. https://onlinecourses.nptel.ac.in/noc21_ma35/preview

3. Specific Learning Outcomes

Experiment	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
1.	Calculation of measures of central tendency	Evaluate the measures of Central tendency for the given data using appropriate statistical tool.	K5
2.	Calculation of measures of dispersion	Evaluate the measures of dispersion for the given data using appropriate statistical tool.	K5
3.	Calculation of Correlation Coefficient	Compare between the two data and give its relation	K4
4.	Finding Lines of Regression	Discover the Lines of Regression incorporating the Correlation Coefficient	K4
5.	Binomial Distribution	Identify and interpret on the Binomial distribution	K3
6.	Poisson Distribution	Identify and interpret on the Poisson distribution	K3
7.	Normal Distribution	Identify and interpret on the Normal distribution	K3
8.	One sample t-test	Experiment with One sample t-test for the appropriate data	K3
9.	Two sample t-test	Make use of two sample t-test for the appropriate data	K3
10.	Chi-square test of independent samples	Test for Chi-square of independent samples	K4
11.	One-way Between-Groups ANOVA	Formulate the hypothesis and perform hypotheses testing using One-way Between-Groups ANOVA	K6
12.	Two-way Between-Groups ANOVA	Formulate the hypothesis and perform hypotheses testing using Two-way Between-Groups ANOVA	K6

13.	Finding differential coefficient of a function	Find differential coefficient of a function	K1
14.	Finding maximum and minimum for a given function	Examine the maximum and minimum for a given function a by applying the concept of derivatives	K4
15.	Population Model	Demonstrate mathematical models in understanding the dynamics of Population model	K2
16.	Lotka - Voltera Models in species interaction;	Demonstrate Lotka - Voltera Models in species interaction	K2
17.	Pollution dispersion model	Demonstrate mathematical models in understanding the dynamics of Pollution dispersion model	K2
18.	Gaussian dispersion modelling in air pollution dispersion and stream water pollution dispersion	Demonstrate Gaussian dispersion modelling in air pollution dispersion and stream water pollution dispersion	K2

4. Mapping Scheme (POs, PSOs and COs)

P20ES2P3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	M	M	H	H	M	M	M	L	H	L	H	H
CO2	M	H	H	H	H	M	M	M	L	H	L	H	H
CO3	M	M	H	H	H	M	M	M	L	H	L	M	H
CO4	H	H	H	H	H	H	M	M	L	H	L	H	H
CO5	H	H	M	H	H	H	L	M	L	M	L	M	H
CO6	H	H	H	H	H	H	H	M	L	H	L	H	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Pre-semester and End-semester Examinations (ESE)
3. Reports, Observation Register, Record Note Books and Viva-voce

Indirect

1. Overall performance assessment, Discussions and co-curricular activities

Course Coordinator: Dr. D. Jasmine

Elective II: BIODIVERSITY CONSERVATION AND ECOLOGICAL RESTORATION

Semester: II **Code: P20ES2:2**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO	Outcomes	K-level	Unit
CO1	Recognize the values of biodiversity.	**K1**	**I**
CO2	Explain the concepts of biodiversity conservation.	**K2**	**II**
C03	Analyze environmental problems and develops skills for ecological restoration.	**K4**	**III**
CO4	Demonstrate managerial skills to manage various ecosystems.	**K3**	**III - V**
C05	Associate Sustainability with agriculture, forest and other environmental components	**K2**	**IV**
CO6	Integrate the knowledge and strategies for environmental management.	**K6**	**V**

2.A. Syllabus

Unit I Introduction (10 Hrs.)

Ecosystem services - classification, values and threats; Ecological engineering - concept, need, applications, design guidelines, functional classes and design principles; Ecological restoration - principles & standards for the practice, approaches and steps

Unit II Strategies of Conservation of Biodiversity (12 Hrs.)

In-situ conservation - Strategic approaches: Strategic Species approach - key stone species, flagship species, umbrella species; Ecosystem approach - IUCN conservation categories; Conservation categories in India Ex-situ conservation; Conservation of plants and animals - botanical gardens, arboretum, seed banks, gene banks, zoos, aquaria, inter specific pregnancy; Conservation strategies in India - concept of sacred groves and traditional knowledge; special conservation projects – project tiger, project elephant.

Unit III Ecological Restoration Strategies (12 Hrs.)

Pollution reduction - phytoremediation, wastewater recycling in wetland, sludge recycling and bio retention of storm water; Ecosystem enhancement - forest restoration, replacement wetland, street side rain garden, integrated fish pond

Unit IV Ecological Restoration Strategies (127 Hrs.)

Ecosystem modification - selective timber harvest, bio manipulation, biological control of eutrophication systems; Ecological sound biotic harvest - sustainable agro-ecosystems, multispecies aquaculture, agroforestry.

Unit V Ecological Management & Restoration (12 Hrs.)

Sustainable forest and wildlife management- Principles and techniques - management of forest fire, human animal conflict, invasive alien species; Concept of sustainable hunting; sustainable grazing, sustainable ecotourism; Ecosystem restoration; Mine land restoration, lake restoration, mangrove restoration, channel aquatic restoration and restoration of hazardous waste sites; Restoration case studies –mangrove, coral reef, river, lake.

B. Topics for Self-study

- **The Great Green Wall** (https://www.unccd.int/actions/great-green-wall-initiative)
- **Social and Ecological Benefits of Restored Wolf Populations** (https://wildlifemanagement.institute/sites/default/files/2016-09/11-Social_and_Ecological.pdf)
- **Rhino Conservation in India: A Great Cause That Needs Us** (https://www.kaziranga-national-park.com/blog/rhino-conservation-in-india/)
- **Olive Ridley Turtles in India - World Turtle Trust** (https://world-turtle-

trust.org/project07.html#:~:text=In%201995%2C%20the%20Wildlife%20Institute,the%20nesting%2C%20and%20hatching%20seasons.)

C. Text Books

1. Clarke GL, Elements of Ecology (2003). John Wiley, London.
2. Krishnamurthy KV, An advanced textbook on Biodiversity: Principles and practice (2004). Oxford and IBH. Publ. Co. New Delhi.
3. Levin SA (Ed.), Encyclopedia of Biodiversity (2000). Academic Press.
4. Perrow MR and Davy AJ, Handbook of Ecological Restoration (2002). Cambridge University Press.
5. Matlock MD and Morgan RA, Ecological Engineering Design Restoring and Conserving Ecosystem Services (2011). John Wiley & Sons.
6. Odum EP, Fundamentals of Ecology (1971). W.B., Saunders Co, Philadelphia and London.

D. References

1. Sharma PD, Ecology and Environment, 13th Ed. (2019). Rastogi Publications, Meerut, India. ISBN: 9789350781227.
2. Singh JS, Singh SP. and Gupta SR, Ecology, Environment and Resource Conservation (2006). Anamaya Publ., New Delhi.
3. Chapman JL and Reiss MJ, Ecology-Principles and applications (1995). Cambridge University Press.
4. Groombridge B (Ed.), Global Biodiversity–status of the Earth's living resources (1994). Chapman & Hall, London.
5. Melchias G. Biodiversity and Conservation (2001). Oxford IBH. New Delhi.

E. Web links

1. http://fes.org.in/source-book/ecological-restoration-source-book.pdf?file=ZG93bmxvYWQvd3AxOS5wZGY=?file=ZG93bmxvYWQvd3AxOS5wZGY=
2. http://wgbis.ces.iisc.ernet.in/energy/water/proceed/proceedings_text/section9/paper3/section9paper3.htm#STR
3. http://www.iucnredlist.org/
4. https://apfisn.net/wp-content/uploads/2018/07/India.pdf
5. https://icrier.org/Urbanisation/events/23-2-15/Ecological.pdf
6. https://www.ncf-india.org/western-ghats/reviving-the-rainforest
7. https://www.sciencedirect.com/science/article/abs/pii/S187220321530024X
8. https://www.unenvironment.org/

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Ecosystem services- classification, values and threats;	Identify the values and threats to Biodiversity	K1
1.2	Ecological engineering-concept, need, applications, design guidelines, functional classes and design principles;	Recognize the tools and guidelines for a better ecological management	K1
1.3	Ecological restoration – principles & standards for the practice, approaches and steps	State the principles and approaches of Ecological restoration	K1
Unit II	**Strategies of Conservation of Biodiversity**		
2.1	In-situ conservation – Strategic approaches: Strategic Species approach -keystone species, flagship species, umbrella species; Ecosystem approach	Associate different approaches for in-situ conservation of biodiversity	K2
2.2	IUCN conservation categories; Conservation categories in India	State the national and international level conservation regulations	K1
2.3	Ex-situ conservation; Conservation of plants and animals – botanical gardens, arboretum, seed banks, gene banks, zoos, aquaria, inter specific pregnancy	Associate different approaches for ex-situ conservation of biodiversity	K2
2.4	Conservation strategies in India-concept of sacred groves and traditional knowledge; special conservation projects– project tiger, project elephant	Review conservation strategies in India and special projects	K2
Unit III	**Ecological Restoration Strategies**		
3.1	Pollution reduction-phytoremediation, waste water recycling in wetland, sludge recycling and bio retention of stormwater	Apply suitable technologies in mitigating environmental issues related to water	K3
3.2	Ecosystem enhancement- forest restoration, replacement wetland, street side raingarden, integrated fish pond	Develop and employ water resource improvement technologies	K3
Unit IV	**Ecological Restoration Strategies**		
4.1	Ecosystem modification- selective timber harvest, bio manipulation, biological control of eutrophication systems	Experiment manipulative ecological modifications for improved wetlands	K3
4.2	Ecological sound biotic harvest-sustainable agro-ecosystems, multispecies aquaculture, agroforestry	Construct ecologically balanced aquaculture/ agroforestry systems	K3

Unit V	Ecological Management & Restoration		
5.1	Sustainable forest and wildlife management- Principles and techniques-management of forest fire, human animal conflict, invasive alien species	Evaluate the sustainability in wildlife management and forest ecosystem management	K5
5.2	Concept of sustainable hunting; sustainable grazing, sustainable ecotourism	Explain sustainability in accessing the forest ecosystem	K4
5.3	Ecosystem restoration; Mine land restoration, lake restoration, mangrove restoration, channel aquatic restoration and restoration of hazardous waste sites	Measure the degraded ecosystems and propose remedial measures	K6
5.4	Restoration case studies–mangrove, coral reef, river, lake	Critically evaluate the coastal ecosystems for effective management	K5

4. Mapping Scheme (POs, PSOs and COs)

P20ES2:2	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	-	L	-	-	-	-	-	-	H	H	-	L
CO2	H	H	L	-	-	L	-	-	-	M	M	L	L
CO3	M	M	L	M	M	H	-	-	-	M	M	-	M
CO4	-	-	-	-	-	-	H	L	L	M	M	H	L
CO5	H	-	-	-	-	M	-	-	-	M	M	L	M
CO6	H	-	-	-	-	M	-	-	-	M	M	L	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.A.Daisy Caroline Mary

Elective III: ENERGY RESOURCES

Semester: II **Code: P20ES2:3**
Credits: 4 **Hours/Week: 4**

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Classify the energy sources (both renewable and non-renewable).	K2	I
CO2	Explain the physical basis of Energy, sources and applications.	K2	II
CO3	Analyze the pros and cons of alternative energy utilization.	K4	III
CO4	Review various techniques to avail non-polluting energy sources.	K2	IV
CO5	Apply the non-polluting energy sources in various fields	K3	V
CO6	Develop green energy technologies.	K6	V

2.A. Syllabus

Unit I Introduction **(11 Hrs.)**

Fossil fuels: classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas. Shale oil, Coal bed Methane, Gas hydrates - Gross-calorific value and net-calorific value.

Unit II Solar Energy **(12 Hrs.)**

Sun as source of energy - solar radiation and spectral characteristics - Principles and generation of solar power - solar collectors - photo-voltaic modules - solar ponds. Domestic and industrial solar panel specifications, calculation and installation methods- Impacts of large-scale exploitation of solar energy sources.

Unit III Wind and Hydro Energy **(14 Hrs.)**

Wind Energy: Introduction, Basic principles of wind energy conversion - wind data and energy estimation – site selection considerations – Basic components of a wind energy conversion system (WEC). Classification of WEC systems, Types of wind machines – Applications of wind energy. Principles of generation of hydro-power, tidal energy, ocean thermal energy conversion, geothermal energy, Impacts of large-scale exploitation of, wind and hydro energy sources.

Unit IV Nuclear Energy **(9 Hrs.)**

Nuclear energy-Introduction, nuclear energy sources, fission and fusion, nuclear fuels, Nuclear reactor – principles and types - Impacts of large-scale exploitation of nuclear energy sources.

Unit V Bioenergy and Energy Usage **(14 Hrs.)**

Bioenergy: Methods to produce energy from biomass. Biomass conversion technologies – Biogas generation-classification and types of biogas plants– construction and Design. Environmental implications of energy use; energy use pattern in India and the world, emissions of CO_2 in developed and developing countries including India, radiative forcing and global warming.

B. Topics for Self-study

- **Energy conservation** (https://www.nature.com/subjects/energy-conservation)
- **Sustainable management of energy resources** (https://www.bbvaopenmind.com/en/articles/current-challenges-in-energy/)
- **The future of energy** (http://futureofenergy.web.unc.edu/tag/hot-topics-in-energy/)
- **Current challenges in Energy** (https://www.bbvaopenmind.com/en/articles/current-challenges-in-energy/)

C. Text Books

1. Rai GD, Non-conventional energy sources (2001). Khanna publishers, New Delhi.
2. Murray RL, Nuclear Energy–An Introduction to Concepts (2009). Systems and Applications of Nuclear Processes, 6th ed. Elsevier.
3. Sukhatme SP, Solar Energy (1996). Tata McGraw Hill publishing company Ltd., New Delhi.
4. Tyagi PD, Fuels from weeds and wastes (1989). Batra Book Service Publishers.

D. References

1. Maheswari A and Parmar G, A Text book of Energy, Ecology Environment and Society, Anmol Publications, New Delhi, 2002.
2. Dunn PD, Appropriate Technology. Macmillan Education limited, 1979.
3. Johnson Gary L, Wind Energy System Prentice - Hall Inc., New Delhi,1985.
4. Trivedi PR and Sudarshan KN, Environment and natural resources conservation, Common Wealth Publishers, New Delhi,1994.
5. Nathanson JA, Basic Environmental Technology: Water supply Management and Pollution, Prentice Hall, 2003.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Fossil fuels: classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas.	Explain the classification of fossil fuels	K2
		Describe the composition of the fossil fuels	K2
		Illustrate the physico-chemical characteristics of the fossil fuels	K3
		Relate the energy content of coal, petroleum and natural gas.	K4
1.2	Shale oil, Coal bed Methane, Gas Hydrates-Gross-calorific value and net-calorific value.	Illustrate coal bed Methane	K4
		Relate Gross calorific value and net calorific value	K5
Unit II	**Solar Energy**		
2.1	Sun as source of energy-solar radiation and spectral characteristics-Principles and generation of solar power-solar collectors-photo-voltaic modules-solar ponds.	Illustrate the principles and generation of solar power	K4
		Design solar collector and Photo voltaic modules	K5
		Explain solar pond	K2
2.2	Domestic and industrial solar panel specifications, calculation and installation methods-Impacts of large-scale exploitation of solar energy sources.	Explain Domestic and industrial solar panel specifications,	K2
		Demonstrate the calculation and installation methods of solar panel	K3

		Explain the impacts of large-scale exploitation of solar energy sources.	K2
Unit III	**Wind and Hydro Energy**		
3.1	Wind Energy: Introduction, Basic principles of wind energy conversion-wind data and energy estimation–site selection considerations	What is wind energy?	K1
		Illustrate the basic principles of wind energy conversion	K3
		Explain wind data and wind energy estimation	K2
		Discuss site selection	K2
3.2	Basic components of a wind energy conversion system (WEC). Classification of WEC systems, Types of wind machines–Applications of wind energy.	Explain the basic components of a wind energy conversion system (WEC)	K2
		Illustrate the Classification of WEC systems,	K3
		Relate the types of wind machines	K4
		Explain the applications of wind energy	K5
3.3	Principles of generation of hydro-power, tidal energy, ocean thermal energy conversion, geothermal energy, Impacts of large-scale exploitation of wind and hydro energy sources.	Explain the principles of hydro -power generation	K3
		Illustrate tidal energy and ocean thermal energy conversion	K3
		Describe geothermal energy	K2
		Discuss the impacts of large-scale exploitation of wind and hydro energy sources.	K2
Unit IV	**Nuclear Energy**		
4.1	Nuclear energy-Introduction, nuclear energy sources, fission and fusion, nuclear fuels	Explain nuclear energy sources	K2
		Differentiate fission and fusion	K4
4.2	Nuclearreactor–principlesandtypes-Impactsoflarge-scaleexploitationofnuclear energy sources.	Illustrate the principle and types of nuclear reactor	K3
		Discuss the impacts of large-scale exploitation of nuclear energy sources	K2
Unit V	**Bioenergy and Energy Usage**		
5.1	Bioenergy: Methods to produce energy from biomass.	Demonstrate various methods to produce energy from biomass	K3
5.2	Biomass conversion technologies–Biogas generation-classification and types of biogas plants–construction and Design	Explain classification and types of biogas generation	K2
		Illustrate construction and design of biogas plant	K3
5.3	Environmental implications of energy use; energy use pattern in India and the world, emissions of CO_2in	Discuss the environmental implications of energy use pattern in India and world	K2

	developed and developing countries including India, radioactive forcing and global warming.	Interpret emissions of CO_2in developed and developing countries including India,	K5
		Explain radioactive forcing and global warming.	K2

4. Mapping Scheme (POs, PSOs and COs)

P20ES2:3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	-	-	-	L	-	-	-	H	M	-	L
CO2	H	H	-	M	L	-	L	-	L	H	M	-	-
CO3	H	H	M	-	-	L	-	-	-	H	-	-	L
CO4	H	H	M	L	L	L	-	L	L	H	M	M	L
CO5	H	H	M	L	-	L	L	L	L	H	L	-	L
CO6	H	H	M	L	L	L	L	-	L	H	M	-	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.D.J.S.Anand Karunakaran

Core VIII: SUSTAINABLE DEVELOPMENT

Semester: III **Code: P21ES308**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Recognize the concepts of environmental sustainability.	**K3**	**I**
CO2	Discuss the components of environmental sustainability from regional to global level.	**K3**	**II**
CO3	Identify various indices to evaluate the sustainability.	**K4**	**III**
CO4	Analyze environmental problems and develops skills to resolve for sustainable development.	**K5**	**III**
CO5	Develop sustainability indices	**K6**	**IV**
CO6	Report various trans-boundary environmental issues through reviewing and analyzing.	**K6**	**V**

2.A. Syllabus

Unit I Sustainable Development: (15 Hrs.)

Sustainable Development; Components; Sustainable Development Goals (SDGs); The Nine Principles of Sustainability; Global conventions; New National Environmental Policy (2006); Agenda 21, Agenda 2030 for Sustainable Development; Millennium Development Goals (MDGs); Johannesburg Plan of Implementation.

Unit II Societal and Economic Sustainability: (15 Hrs.)

Societal Sustainability- Sustainable Governance Indicators; Social Development Indicators (SDIs); Human Development Index (HDI); Sustainable Society Index (SSI); Economic sustainability- GDP per capita; Gini coefficient; ISO 14007:2019.

Unit III Environmental Sustainability: (15 Hrs.)

Water management (SWM); Rain water harvesting; Watershed Management; Sustainable Land Management (SLM); Land use pattern; Land degradation; Sustainable agriculture; Integrated Pests and Weed Management, Integrated Farming; Sustainable Forest Management (SFM); Social forestry; Joint Forest Management.

Unit IV Environmental Sustainability: (15 Hrs.)

Ecological Indicators and footprint; COVID 19: Challenges and Importance of Environmental Sustainability; Environmental Management System and Strategy; Environmental Performance Index; Environmental Vulnerability Index; Marketable pollution permits; Emission Standards and Effluent Charges; Transferable Pollution Credits. ISO14001:2015.

Unit V Achieving Sustainability: (15 Hrs.)

Population, Income, Health Care and Urbanization; Poverty, Hunger and Malnutrition; Inequality and Social Exclusion; Conflict, Peace, and Humanitarian Response; Virtual Water Trade; Trans-boundary problems- Love Canal disaster; Cauvery Water Dispute; Hazardous Waste Management, Oil Spills; Petroleum Resource Disputes.

B. Topics for Self-study:

- **Mixed farming** (https://www.agrifarming.in/mixed-farming-and-mixed-cropping-information-guide)
- **Multiple cropping** (https://www.drishtiias.com/daily-updates/daily-news-analysis/multi-cropping)
- **Improved health for sustainable** (https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals)
- **Environment Education for Sustainability** (https://yeenet.eu/archives/images/stories/PUBLICATIONS/Booklets/Environmental_education_for_sustainability/Environmental_Education_for_Sustainability_booklet.pdf)

C. Text Books

1. Blewitt J, Understanding Sustainable Development (2008). Earthscan. ISBN: 9781844074556.
2. Manahan SE, Environmental Science and Technology- A Sustainable Approach to Green Science and Technology 2nd Ed. (2006). CRC Press.
3. Brandon P, Lombardi P, Evaluating Sustainable Development (2005). Wiley-Blackwell.
4. Rogers PP, Jalal KF and Boyd JA, An introduction to sustainable development (2007). Earthscan Publications Ltd.
5. Chinmay Chakraborty, Swapnila Roy, Susmita Sharma and Tien Anh Tran. The Impact of COVID-19 Pandemic on Green Societies (2021). Springer. ISBN: 978-3-030-66490-9.
6. Chinmay Chakraborty, Swapnila Roy, Susmita Sharma and Tien Anh Tran. The Impact of COVID-19 Pandemic on Green Societies (2021). Springer.ISBN:978-3-030-66490-9.

D. Reference Books

1. Nandhithakrishna, Environmental Laws of India – An Introduction, C.P.R. Environmental Education Centre, Chennai, 1998.
2. Canter LW, Environmental impact assessment, McGraw Hill Book co. NY, 1977.
3. Centre for Science and Environment, The State of India's Environment: The second Citizen's Report, CSE, New Delhi, 2008.
4. Deborah Reyes, Sustainable Development: Process, Challenges and Prospects, 2015. Nova Publisher. ISBN: 978-1-63482-506-1

E. Web Links

1. http://css.umich.edu/factsheets/social-development-indicators-factsheet
2. http://www.fao.org/forestry/sfm/en/
3. https://www.who.int/water_sanitation_health/resourcesquality/wpcchap6.pdf
4. https://iwlearn.net/manuals/tda-sap-methodology/development-of-the-tda/identification-prioritisation-of-the-transboundary/what-is-a-transboundary-problem#:~:text=A%20transboundary%20problem%20is%20an,affecting%20(or%20impacting)%20another.
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7220565/

3. Specific Learning Outcome

Unit	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Sustainable Development**		
1.1	Sustainable Development, Components; Sustainable Development Goals (SDGs); The Nine Principles of Sustainability; Global conventions;	Able to learn, recall and Identify the Sustainable development components and goals.	K2
		Relate the nine principles of Sustainability and Global Conventions	K3
1.2	New National Environmental Policy (2006); Agenda 21, Agenda 2030 for Sustainable Development; Millennium Development Goals (MDGs); Johannesburg Plan of Implementation.	Apply the New National Environmental Policy (2006); Make use of Agenda 21, Agenda 2030 for Sustainable Development; Millennium Development Goals (MDGs); Johannesburg Plan of Implementation.	K3
Unit II	**Societal and Economic Sustainability**		
2.1	Societal and Economic Sustainability Societal Sustainability- Sustainable Governance Indicators; Social Development Indicators (SDIs); Human Development Index (HDI); Sustainable Society Index (SSI);	Able to Categories the Societal and Economic Sustainability- Sustainable Governance Indicators; Social Development Indicators (SDIs); Human Development Index (HDI); Sustainable Society Index (SSI);	K4
2.2	Economic sustainability- GDP per capita; Gini coefficient; ISO 14007:2019.	Estimate the Economic sustainability- GDP per capita; Gini coefficient; ISO 14007:2019	K4
Unit III	**Environmental Sustainability**		
3.1	Environmental Sustainability Water management (SWM); Rain water harvesting; Watershed Management; Sustainable Land Management (SLM); Land use pattern; Land degradation;	Measure the Environmental Sustainability Water management (SWM); Rain water harvesting; Watershed Management; Sustainable Land Management (SLM); Land use pattern; Land degradation;	K5
3.2	Sustainable agriculture; Integrated Pests and Weed Management, Integrated Farming; Sustainable Forest Management (SFM); Social forestry; Joint Forest Management.	Categories the Sustainable agriculture; Integrated Pests and Weed Management, Integrated Farming; Sustainable Forest Management (SFM); Social forestry; Joint Forest Management.	K4

Unit IV	Environmental Sustainability		
4.1	Environmental Sustainability Ecological Indicators and footprint; Environmental Management System and Strategy; Environmental Performance Index; Environmental Vulnerability Index; Marketable pollution permits; Emission Standards and Effluent Charges; Transferable Pollution Credits. ISO14001:2015.	Illustrate the Environmental Sustainability Ecological Indicators and footprint; Able to build the Environmental Management System and Strategy; Environmental Performance Index; Environmental Vulnerability Index; Marketable pollution permits.	K3
		Value the Emission Standards and Effluent Charges; Transferable Pollution Credits. ISO14001:2015.	K5
Unit V	**Achieving Sustainability**		
5.1	Achieving Sustainability Population, Income, Health Care and Urbanization; Poverty, Hunger and Malnutrition; Inequality and Social Exclusion; Conflict, Peace, and Humanitarian Response; Virtual Water Trade.	Estimate the Sustainability Population, Income, Health Care and Urbanization; Poverty, Hunger and Malnutrition;	K5
		Interpret Inequality and Social Exclusion; Conflict, Peace, and Humanitarian Response; Virtual Water Trade	K2
5.2	Trans-boundary problems Love Canal disaster; Cauvery Water Dispute; Hazardous Waste Management, Oil Spills; Petroleum Resource Disputes.	Elaborate the Trans boundary problems. Rate the Cauvery water dispute, oil spills, Petroleum disputes and Hazardous waste management.	K6

4. Mapping Scheme (POs, PSOs and COs)

P21ES308	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	L	L	-	-	-	-	-	M	-	H	M	-	M
CO2	H	M	-	H	L	-	-	L	L	H	L	-	-
CO3	L	H	M	-	-	L	-	-	-	H	-	-	H
CO4	H	L	-	L	M	L	-	H	L	H	M	M	H
CO5	H	H	M	L	-	L	M	L	L	H	L	-	H
CO6	H	H	M	L	-	L	M	L	L	H	L	-	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.M.Immanuel Sagayaraj

Core IX: ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

Semester: III **Code: P20ES309**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Define the concepts of water distribution systems, sewer networks and working principles.	**K3**	**I**
CO2	Assess the pollution concentration incorporating meteorological factors through computer modelling	**K3**	**II**
CO3	Choose right methods of sampling and analysis for air pollution monitoring	**K4**	**III**
CO4	Apply the basic engineering principles in controlling the air / noise pollution.	**K5**	**III**
CO5	Design the appropriate water/waste water treatment methods, air noise pollution control techniques solid waste disposal methods	**K6**	**IV**
CO6	Plan and organize solid waste collection, and 3-R strategies	**K5**	**V**

2.A. Syllabus

Unit I Water and Waste Water **(15 Hrs.)**

Water sources for domestic water Supply. Treatment of Water – processes and operations of water treatment. Water Distribution and Supply - Layout of water distribution systems. Wastewater Treatment – Primary, Secondary and advanced treatment: Physical, Chemical and Biological unit processes for purifying the wastewater. Design, Layout and specifications of Industrial and Municipal wastewater treatment systems. Advanced Oxidation Process- Introduction, Types, photocatalysis, photolysis, sonolysis, electrochemical oxidation technologies, ozone-based processes, Fenton-based processes, Application of different advanced oxidation processes for the degradation of pollutants.

Unit II Air Pollution Meteorology: **(16 Hrs.)**

Meteorological factors in air pollution survey. Meteorological factors in air pollution dispersion: wind – preparation of wind roses, Atmospheric stability – Determination of Atmospheric stability, plume behavior, Mixing Height, Ventilation coefficient. Air pollution dispersion Modelling – introduction.

Unit III Air Pollution Monitoring: **(14 Hrs.)**

Air pollution monitoring, principles of sampling and analysis of particulate and gaseous contaminants. Noise pollution monitoring: Noise measurements – decibel scale, reporting of noise pollution – data analysis and computation of L_{min}, L_{max}, L_{50}, L_{eq}. Types of Noise.

Unit IV Air Pollution Control: **(15 Hrs.)**

Control of particulate emissions - settling chambers, centrifugal collectors, wet collectors, fabric filters and Electrostatic precipitators, their techniques. Control of gaseous contaminants - Adsorption and Absorption techniques. Condensation and combustion techniques. Noise pollution control – Engineering Control - control at source, Control along the path - barriers and control at receiver.

Unit V Solid Waste Control: **(15 Hrs.)**

Principles and methods of Municipal solid waste collection, Recovery, Reuse and Recycling of useful solid wastes. Treatment and design of disposal mechanisms - Land filling, composting and incineration techniques.

B. Topics for Self-study

- **Waste Water Treatment Design and Disposal Mechanism** (https://www.iwapublishing.com/sites/default/files/ebooks/9781780402086.pdf)
- **Technologies for Air Pollution Control** (https://www.eolss.net/sample-chapters/c09/e4-11-05.pdf)
- **Managing Air Quality** (https://www.epa.gov/air-quality-management-process/managing-air-quality-control-strategies-achieve-air-pollution)
- **Risk Modelling** (https://analyticsindiamag.com/top-9-online-credit-risk-modelling-courses-one-must-learn-in-2020/)

C. Text Books

1. Duggal KN, Elements of Environmental Engineering (1998). Chand and company Ltd., New Delhi. ISBN: 9788121915472.
2. Masters GM and Ela PW, Introduction Environmental Engineering and Science (2013). Pearson Education Ltd. ISBN: 9781292038179.
3. Peavy HS, Rowe D and Tchobanoglous G, Environmental Engineering (2017). Mc Graw Hill Education. ISBN: 9789351340263.
4. Davis ML and Cornwell DA, Introduction to Environmental Engineering (1991). McGraw-Hill, Inc., New York. ISBN: 0070159114.

D. Reference Books

1. Metcalf and Eddy, Inc. Waste water Engineering: Treatment, Disposal Reuse (1979). Tata McGraw Hill Publishing Co., New Delhi. ISBN: 0070994617
2. Rao CS, Environmental Pollution Control Engineering (2006). New Age International (P) Ltd., New Delhi. ISBN: 812241835X.
3. Vesilind PA, Morgan SM and Heine LG, Introduction to Environmental Engineering, 3rd Ed., Cengage Learning, Australia. ISBN: 9780495295853.
4. Liu David HF and Liptak BG, Environmental Engineers Handbook, 2nd Ed. (1997). Lewis Publishers, Boca Raton. ISBN: 0849399718.
5. Hammer MJ, Water and Wastewater Technology (2008). Pearson Prentice Hall. ISBN: 9780131745421.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Water and Waste Water**		
1.1	Water sources for domestic water Supply.	Identify different water sources for domestic supply	K2
1.2	Treatment of Water–processes and operations of water treatment.	Design various treatment processes and operations for drinking water	K5
1.3	Water Distribution and Supply-Layout of water distribution systems.	Illustrate the water distribution and supply layout	K3

1.4	Waste water Treatment– Primary, Secondary and advanced treatment: Physical, Chemical and Biological unit processes for purifying the wastewater. Design, Layout and specifications of Industrial and Municipal wastewater treatment systems.	Design and Plan the waste water treatment systems for sewage and industrial effluents	K5
1.5	Advanced Oxidation Process-Introduction, Types, photocatalysis, photolysis, sonolysis, electrochemical oxidation technologies, ozone-based processes, Fenton-based processes, Application of different advanced oxidation processes for the degradation of pollutants.	Apply various advanced techniques in waste water treatment	K3
Unit II	**Air Pollution Meteorology**		
2.1	Meteorological factors in air pollution survey. Meteorological factors in air pollution dispersion: wind– preparation of wind roses, Atmospheric stability–Determination of Atmospheric stability, plume behaviour, Mixing Height, Ventilation coefficient.	Prepare wind roses and estimate the stability conditions, mixing height, ventilation coefficient to interpret the dispersion of pollutants	K5
2.2	Air pollution dispersion Modelling –introduction.	Estimate the pollutant concentration using models incorporating the meteorological factors	K6
Unit III	**Air Pollution Monitoring**		
3.1	Air pollution monitoring, principles of sampling and analysis of particulate and gaseous contaminants.	Plan air pollution monitoring by choosing right methods of sampling and analysis	K5
3.2	Noise pollution monitoring: Noise measurements–decibel scale, Reporting of noise pollution–data analysis and computation of L_{min}, L_{max}, L_{50}, L_{eq}. Types of Noise.	Assess the extent of noise pollution by monitoring and data analysis	K6
Unit IV	**Air Pollution Control**		
4.1	Control of particulate emissions-settling chambers, centrifugal collectors, wet collectors, fabric filters and Electro static precipitators, their techniques.	Design particulate air pollution control devices	K5

4.2	Control of gaseous contaminants-Adsorption and Absorption techniques. Condensation and combustion techniques.	Propose suitable control device for control of gaseous contaminants	K5
4.3	Noise pollution control– Engineering Control-control at source, Control along the path-barriers and control at receiver.	Plan appropriate noise control measures at source, along the path and at receiver	K5
Unit V	**Solid Waste Control**		
5.1	Principles and methods of Municipal solid waste collection	Explain the different methods of municipal solid waste collection	K2
	Recovery, Reuse and Recycling of useful solid wastes.	Employ 3-R in managing solid wastes	K3
5.2	Treatment and design of disposal mechanisms-Landfilling, composting and incineration techniques.	Design and devise suitable treatment / disposal of Solid Waste Methods	K5

4. Mapping Scheme (POs, PSOs and COs)

P20ES309	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	L	-	-	L	-	-	L	M	M	M	H
CO2	H	L	L	H	M	M	L	-	-	H	M	M	L
CO3	H	-	L	M	H	-	L	L	-	H	H	M	-
CO4	H	-	L	M	M	H	L	-	L	H	M	H	M
CO5	H	-	M	H	M	H	L	-	L	H	L	L	L
CO6	H	L	L	M	M	H	L	L	M	H	L	M	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.C.Ravichandran

Core X: ENVIRONMENTAL IMPACT ASSESSMENT

Semester: III **Code: P20ES310**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	State the basic concepts of Environmental Impact Assessment	**K5**	**I**
CO2	Discuss the recent developments of Environmental Impact Assessment	**K6**	**II**
CO3	Interpret various methods of Environmental Impact Assessment	**K6**	**III**
CO4	Appraise the methods of preparation of Environmental Impact Assessment reports	**K5**	**IV**
CO5	Perform a health risk analysis	**K5**	**V**
CO6	Organize risk assessment, Life Cycle Analysis and Cost-Benefit analysis	**K5**	**V**

2.A. Syllabus

Unit I Environmental Impact Assessment: (13 Hrs.)

History and perspectives. EIA – Definition and Terminologies. Regulatory framework in India, EIA guidelines, Govt. of India EIA Notifications 1994. 2006 and amendments up to 2020. NABET criteria for EIA consultants NRBT criteria for EIA consultants, NABL.

Unit II Rapid and Comprehensive EIA, Methodologies: (15 Hrs.)

Adhoc, Overlays, Matrix, Checklist and Network approach. Battle Columbus Technique and modeling. EIA Process, EIS and EMP. Public Consultation, list of industries attracting EIA, Environmental Clearance. Composition of expert committee, Terms of Reference, EIA Report Preparation.

Unit III Environmental Impact Analysis and Assessment: (15 Hrs.)

Air, Noise, Water, Land, flora and fauna, Socio – economic and biotic environment. Environmental setting, Identification, evaluation and prediction of environmental impacts. Case studies of EIA of developmental projects – Hydel project, Oil Pipeline project, East Coast Road, Mining project.

Unit IV Environmental Audit: (15 Hrs.)

Guidelines, planning for Environmental Audit. Life cycle analysis, Cost Benefit Analysis. Industrial safety and OHSA systems and ISO 27001. 45001 & OHSAS 18001, Environmental Management Systems. Cleaner production technologies, Eco-mark and Eco labelling schemes.

Unit V Principles of Risk Assessment: (17 Hrs)

Human Health Risk Assessment, Ecological Risk Assessment, Probabilistic Risk Assessment. The role of Risk assessment in Environmental Management decision. Evaluation of human health risks associated with airborne exposures. Risk management and risk communication. Life Cycle Assessment and Cost Benefit Analysis.

B. Topics for Self-study:

- **Environmental monitoring and auditing** (https://www.iaia.org/wiki-details.php?ID=15)
- **Mitigation banking** (https://environmentalbanking.org/)
- **Use of Internet in the EIA process** (https://www.iaia.org/eia-index-of-websites.php)
- **Methods and tools for EIA** (https://www.shelftercluster.org/sites/default/files/docs/GRRT%203%20-%20Environmental%20Impact%20Assessment%20Tools%20and%20Techniques.pdf)

C. Text Books

1. Canter LW, Environmental Impact Assessment (1977). McGraw Hill Book Co., New York.
2. Munn RE, Environmental Impact Assessment (1982). McGraw Hill Book Co., New York.
3. Rau JG and Wooten DC, Environmental Impact Analysis Handbook (1980). McGraw Hill Book Co., New York.

D. References

1. Cutter L, Environment risks and hazards (1999). Prentice Hall of India Private Limited, New Delhi.
2. Asante. Duah K, Risk Assessment in Environmental Management (1998). John Wiley and Sons, New York. ISBN: 9780471981473.
3. Calow P, Hand Book of Environmental Risk Assessment and Management (1998). Blackwell, Swence, London. ISBN: 9780865427327.
4. Westman WE, Ecology, Impact Assessment and Environmental Planning (1985). John Willey and Sons, New York.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Environmental Impact Assessment**		
1.1	Environmental Impact Assessment History and perspectives. EIA – Definition and Terminologies. Regulatory framework in India, EIA guidelines, Govt. of India EIA Notifications 1994. 2006 and amendments up to 2020. NABET criteria for EIA consultants NRBT criteria for EIA consultants, NABL.	Recall the Environmental Impact Assessment History and perspectives, Definition and Terminologies.	K1
		Interpret the Regulatory framework in India, EIA guidelines, Govt. of India EIA Notifications 1994. 2006 and amendments up to 2020. NABET criteria for EIA consultants NRBT criteria for EIA consultants, NABL.	K5
Unit II	**Rapid and Comprehensive EIA, Methodologies**		
2.1	Rapid and Comprehensive EIA, Methodologies Adhoc, Overlays, Matrix, Checklist and Network approach. Battle Columbus Technique and modelling.	Explain the Rapid and Comprehensive EIA, Methodologies.	K2
		Adapt Adhoc, Overlays, Matrix, Checklist and Network approach. Battle Columbus Technique and modelling	K6
2.2	EIA Process, EIS and EMP. Public Consultation, list of	Formulate the EIA Process, EIS and EMP.	K6

	industries attracting EIA, Environmental Clearance. Composition of expert committee, Terms of Reference, EIA Report Preparation.	List out the Public Consultation, list of industries attracting EIA, Environmental Clearance. Composition of expert committee, Terms of Reference, EIA Report Preparation.	K1
Unit III	**Environmental Impact Analysis and Assessment**		
3.1	Environmental Impact Analysis and Assessment Air, Noise, Water, Land, flora and fauna, Socio – economic and biotic environment. Environmental setting, Identification, evaluation and prediction of environmental impacts.	Analyze and assess the Environmental Impact on Air, Noise, Water, Land, flora and fauna, Socio – economic and biotic environment.	K4
		Evaluate the evironmental setting, Identification, evaluation and prediction of environmental impacts.	K5
3.2	Case studies of EIA of developmental projects – Hydel project, Oil Pipeline project, East Coast Road, Mining project.	Mark the Case studies of EIA of developmental projects – Hydel project, Oil Pipeline project, East Coast Road, Mining project.	K5
Unit IV	**Environmental Audit**		
4.1	Environmental Audit Guidelines, planning for Environmental Audit. Life cycle analysis, Cost Benefit Analysis. Industrial safety and OHSA systems and ISO 27001. 45001 & OHSAS 18001.	Formulate the Environmental Audit Guidelines, planning for Environmental Audit. Life cycle analysis, Cost Benefit Analysis.	K6
		Predict the Industrial safety and OHSA systems and ISO 27001. 45001 & OHSAS 18001.	K5
4.2	Environmental Management Systems. Cleaner production technologies, Eco-mark and Eco labelling schemes.	Explain Environmental Management Systems. Cleaner production technologies, Eco-mark and Eco labelling schemes.	K2
Unit V	**Principles of Risk Assessment**		
5.1	Principles of Risk Assessment Human Health Risk Assessment, Ecological Risk Assessment, Probabilistic Risk Assessment. The role of Risk assessment in Environmental Management decision.	Apply and assess the principles of Risk Assessment Human Health Risk Assessment, Ecological Risk Assessment, Probabilistic Risk Assessment.	K3
		Measure the role of Risk assessment in Environmental Management decision.	K5
5.2	Evaluation of human health risks associated with airborne exposures. Risk management and risk communication. Life Cycle Assessment and Cost Benefit Analysis.	Evaluate the human health risks associated with airborne exposures, Risk management and risk communication, Life Cycle Assessment and Cost Benefit Analysis	K5

4. Mapping Scheme (POs, PSOs and COs)

P20ES310	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	L	L	-	-	M	-	-	M-	-	H	M	-	H
CO2	L	M	-	H	L	-	-	L	L	H	L	-	H
CO3	L	M	M	-	-	L	-	-	-	H	-	-	L
CO4	H	L	L	-	M	L	-	H	L	H	M	M	H
CO5	H	-	M	L	-	L	M	L	L	H	L	-	H
CO6	H	-	M	L	-	L	M	L	L	H	L	-	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Prof.A.Alagappa Moses

Core XI: INSTRUMENTATION FOR ENVIRONMENTAL SCIENCES

Semester: III **Code: P20ES311**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of this course the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Explain the basic principles of various instruments used in environmental monitoring/sampling and analysis.	K2	I
CO2	Summarize instruments available for physical/chemical and biological assessment.	K2	II
CO3	Apply the sampling and sample processing techniques.	K3	III
CO4	Choose the suitable instruments for environmental assessment.	K3	IV
CO5	Examine environmental samples with higher-end instruments	K4	IV
CO6	Evaluate using the different advanced analytical tools in environmental management.	K4	V

2.A. Syllabus

Unit I Introduction **(15 Hrs.)**

Evaluations of Basic Physical Properties; Thermal Methods; Electro migration Methods; Electrochemical Methods; Absorption Laws; Optical Sensors; Biosensors; Sample Preparation- Limit of Detection (LOD); Limit of Quantification (LOQ); Methods of Calibration.

Unit II Microscopy **(15 Hrs.)**

Surface Analysis- Microscopic Techniques; Simple, Compound and Inverted Microscopy; Fluorescence Microscopy; Micrometry; Electron Microscopy- SEM and TEM

Unit III Spectroscopy **(17 Hrs.)**

Principles, Mechanism and Applications of Spectroscopy- UV-Visible; Atomic Absorption Spectroscopy (AAS); Nuclear Magnetic Resonance Spectroscopy (NMR); Infrared Spectroscopy-FTIR; X-ray Diffraction Spectroscopy (XRD); Mass Spectrometry (MS). Ion Scattering Spectroscopy.

Unit IV Chromatography **(13 Hrs.)**

Principles, Mechanism and Applications of Chromatography- Liquid Chromatography (LC); High Performance Liquid Chromatography (HPLC); Gas Chromatography (MS); Ion Chromatography; Thin Layer Chromatography (TLC).

Unit V Instrumentation for Thermal and Molecular Studies **(15 Hrs.)**

Principles, Mechanism and Applications of Thermal Analysis- TGA Instrumentation; Instrumentation for Molecular Studies- Electrophoresis; Polymerase Chain Reactor (PCR).

B. Topics for Self-study

- **Class Notes on principles of instrumental analysis** (http://www.chem.latech.edu/~upali/chem466/notes&slides.htm)
- **Important Considerations in Sample Preparation** (https://lab-training.com/2015/01/05/important-considerations-sample-preparation/)
- **Types of solvent extraction** (http://www.pitt.edu/~ceder/lab2/extraction.html)
- **Statistics for Biologists** (https://www.nature.com/collections/qghhqm)

C. Text Books

1. Robinson JW, Skelly Frame EM and Frame IIGM (2004). Undergraduate instrumental analysis, CRC Press. ISBN:9780824753597, 9780203997307.
2. Guaraglia DO and Pousa JL, Introduction to modern instrumentation: for hydraulics and environmental sciences (2014). De Gruyter Open. ISBN: 9783110401721.
3. Down RD and Lehr JH (Editors), Environmental Instrumentation and Analysis Handbook (2004). John Wiley and Sons. ISBN: 9780471463542.

D. Reference Books

1. William H, Merritt L, Dean DA and Settle FA, Instrumental Methods of Analysis, CSS publishers, New Delhi, 1986.
2. Sharma BK, Instrumental Methods of Chemical Analysis, Goel Publishing house, Meerut, 1999.
3. Willard LL, Merritt and John and Dean, Instrumental Methods of analysis, D Van Nostrand Company, New York, 1966.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Evaluations of Basic Physical Properties;	Choose the research that they want to carry out.	K1
1.2	Thermal Methods; Electro migration Methods; Electrochemical Methods;	Identify the principles of research methods and instruments.	K3
1.3	Absorption Laws; Optical Sensors; Biosensors; Sample Preparation- Limit of Detection (LOD); Limit of Quantification (LOQ); Methods of Calibration.	Apply and Handle the instruments and perform the analysis	K3
Unit II	**Microscopy**		
2.1	Surface Analysis- Microscopic Techniques;	Identify instruments required for their research experiments.	K3
2.2	Simple, Compound and Inverted Microscopy; Fluorescence Microscopy; Micrometry; Electron Microscopy- SEM and TEM	Collect appropriate quantitative and qualitative research data, and analyze.	K4
Unit III	**Spectroscopy**		
3.1	Principles, Mechanism and Applications of Spectroscopy	Outline the principles of research methods and instruments.	K2
3.2	UV-Visible; Atomic Absorption Spectroscopy (AAS); Nuclear Magnetic Resonance Spectroscopy (NMR); Infrared Spectroscopy-FTIR; X-ray Diffraction Spectroscopy (XRD); Mass Spectrometry (MS); Ion Scattering Spectroscopy.	Explain and Acquire skills to handle the scientific instruments.	K2

Unit IV	**Chromatography**		
4.1	Principles, Mechanism and Applications of Chromatography	Identify research problems and design their specific research plans to conduct research.	K3
4.2	Liquid Chromatography (LC); High Performance Liquid Chromatography (HPLC); Gas Chromatography (MS); Ion Chromatography; Thin Layer Chromatography (TLC).	Classify different instrumental techniques and their applications in ecological and environmental science research.	K2
Unit V	**Instrumentation for Thermal and Molecular Studies**		
5.1	Principles, Mechanism and Applications of Thermal Analysis	Examine and provide an overview of measurement principles and the advantages and limitations associated with different instrumental techniques	K4
5.2	TGA Instrumentation; Instrumentation for Molecular Studies- Electrophoresis; Polymerase Chain Reactor (PCR).	Choose and provide an overview of the scientific background and theory behind the workings of these instruments.	K5

4. Mapping Scheme (POs, PSOs and COs)

P20ES311	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	-	L	L	-	-	H	M	-	M
CO2	H	H	M	-	M	-	-	L	-	H	L	M	L
CO3	H	H	H	L	M	L	-	-	L	H	M	-	L
CO4	H	M	H	-	L	M	L	-	L	H	L	L	L
CO5	H	M	H	-	L	M	L	-	L	H	L	L	L
CO6	H	H	L	L	-	L	-	-	L	H	L	-	-

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.T.Nalini

Core Practical IV: WATER POLLUTION AND ITS CONTROL ENGINEERING, SOIL POLLUTION AND GIS APPLICATIONS

Semester: III **Code: P20ES3P4**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Inspect the characteristics of water	**K4**	**Unit I**
CO2	Test the demand parameters of water	**K6**	**Unit II**
CO3	Measure the suitability of water for domestic and irrigation purposes.	**K5**	**Unit III**
CO4	Develop water treatment units	**K6**	**Unit III**
CO5	Appraise the quality of soil and the extent of pollution.	**K5**	**Unit IV**
CO6	Apply GIS in water pollution and soil pollution.	**K3**	**Unit V**

2.A. Syllabus

Unit I Parameters based on Drinking Water Quality Standards/irrigation water quality: (15 Hrs.)

pH, electrical conductivity, turbidity, total dissolved solids, ammonia (as total ammonia – N), Calcium, Chloride, Fluoride, Iron, Iron, magnesium, nitrate, sulphate, total alkalinity, total hardness, sodium, potassium, Sodium Absorption ratio, MPN

Unit II Demand Parameters: (10 Hrs.)

Dissolved Oxygen, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) (one sample from clear water source and another sample from a polluted water preferably sewage or industrial effluent)

Unit III Water pollution Control Engineering: (20 Hrs.)

Calculation and designing of Sedimentation Tank, Clariflocculator; Calculation and designing of Aeration Tank; Aeration, fixing optimum pH and optimum coagulant dose using Jar test apparatus.

Unit IV Soil Analysis: (10 Hrs.)

pH, Electrical Conductivity, Alkalinity, Total Organic Matter, Total Phosphorous, Total Nitrogen, Sodium, Potassium, Ca, Mg, C:N ratio. Soil texture- sand, silt, clay.

Unit V Application of GIS: (20 Hrs.)

Mapping of water chemistry-based BIS Drinking water specifications. Mapping of soil quality based on TNAU specifications.

C. Text Books

1. Patnaik, P, Handbook of Environmental Analysis–Chemical Pollutants in Air; Water; Soil and Solid wastes (1997). Lewis publishers, Boca Raton.
2. APHA Standard Methods for the Examination of Water and Wastewater 21st Ed. (2005). American Water Works Association Publisher. ISBN: 9780875530475.

D. Reference Books

1. Trivedy RK, Goel PK and Trisal L, Practical Methods in Ecology and Environmental Sciences (1987). Environmental Publications, Karad.
2. Saxena MM, Environmental Analysis Water, Soil and Air (1987). Agro Botanical Publishers, India. ISBN: 8185031223.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Parameters based on Drinking Water Quality Standards/irrigation water quality**		
1.1	Parameters based on Drinking Water Quality Standards /irrigation water quality pH, electrical conductivity, turbidity, total dissolved solids, ammonia (as total ammonia–N), Calcium, Chloride, Fluoride, Iron, magnesium, nitrate, sulphate, total alkalinity, total hardness, sodium, potassium, Sodium Absorption ratio, MPN	Discuss the principles, concept and Importance of parameters	K6
		Analyze the different water samples	K4
		Compare the results with the standards	K4
		Determine the condition of the water sample	K5
		Recommend water samples for the human consumption	K5
		Formulate the rules and regulation for the future conservation	K6
Unit II	**Demand Parameters**		
2.1	Demand Parameters: Dissolved Oxygen, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) (on a sample from clear water source and another sample from a polluted water preferably sewage or industrial effluent)	Discuss the principles, concept and Importance of parameters	K6
		Analyze the different water samples	K4
		Compare the results with the standards	K4
		Determine the condition of the water sample	K5
		Recommend water samples for the human consumption	K5
		Formulate the rules and regulation for the future conservation	K6
Unit III	**Water pollution Control Engineering**		
3.1	Water pollution Control Engineering: Calculation and designing of Sedimentation Tank, Clariflocculator; Calculation and designing of Aeration Tank; Aeration, fixing optimum Hand optimum coagulant dose using Jar test apparatus.	Discuss the principles, concept and Importance of treatment methods	K6
		Illustrate the different treatment processes	K2
		Construct the different treatment processes	K6
		Experiment with optimum coagulant dose with Jar test apparatus	K3
Unit IV	**Soil Analysis**		
4.1	Soil Analysis: pH, Electrical Conductivity, Alkalinity, Total Organic Matter, Total Phosphorous, Total Nitrogen, Sodium, Potassium, Ca, Mg, C/N ratio. Soil texture: sand,	Discuss the principles, concept and importance of the various soil parameters	K6
		Estimate the different parameters of soil samples	K6
		Compare the results with standards	K5

	silt, clay.	Determine the condition of the soil samples	K5
		Recommend soil samples for the agriculture activities	K5
Unit V	**Application of GIS**		
5.1	Application of GIS: Mapping of water chemistry-based BIS Drinking water specifications. Mapping of soil quality based on TNAU specifications	Discuss the application of GIS mapping on water and soil study specification	K6
		Develop the mapping of water and soil specifications.	K6

4. Mapping Scheme (POs, PSOs and COs)

P20ES3P4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	L	L	M	L	L	-	L	L	M	M	M
CO2	H	H	M	H	M	M	L	L	L	H	L	M	M
CO3	H	H	M	M	M	M	L	L	L	H	L	M	M
CO4	H	H	M	H	M	M	L	L	L	H	L	M	M
CO5	H	H	H	H	M	M	M	H	H	H	M	M	M
CO6	M	M	M	H	H	L	M	L	L	M	M	M	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Pre-semester and End-semester Examinations (ESE)
3. Reports, Observation Register, Record Note Books and Viva-voce

Indirect

1. Overall performance assessment, Discussions and co-curricular activities

Course Coordinator: Dr.C.Ravichandran

Elective IV: REMOTE SENSING AND GIS FOR ENVIRONMENTAL SCIENCES

Semester: III **Code: P20ES3:4**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Explain the principles and applications of remote sensing in environmental management	**K2**	**I**
CO2	Explain the principles and applications of Geographic Information System	**K2**	**II**
CO3	(GIS) technologies in environmental management	**K4**	**III**
CO4	Recognize the application of GIS in Land use/cover management.	**K6**	**III**
CO5	Discuss the applications of GIS in mapping of ground water potential zones.	**K6**	**IV**
CO6	Develop GIS maps of environmental resources, pollution and disasters for environmental management and Disaster management	**K6**	**V**

2.A. Syllabus

Unit I Fundamentals of Remote Sensing: (15 Hrs.)

Energy sources and radiation principles–Electromagnetic spectrum: Processes and elements of Electromagnetic Remote Sensing –Interaction of electromagnetic energy with Earth's atmosphere and surface features –Spectral reflectance curve of vegetation, soil and water– Types of satellites–Sensor resolution: spatial, spectral, temporal and radiometric. Fundamentals of image interpretation techniques.

Unit II Principles of Geographic Information System (GIS): (10 Hrs.)

Concepts and Components of GIS – Hardware, software and organizational Context-Data– (spatial and non-spatial)–Maps (types of maps)–Projection (types of projection) Data input (digitizer- scanner-editing) Raster and vector data structure- analysis using raster and vector data- retrieval, reclassification, overlaying, buffering-Data output.

Unit III Applications of Remote Sensing and GIS: (10 Hrs.)

Land use/land cover Mapping; Basic concept and classification and Land use change detection mapping – Mapping of soil erosion prone areas – Mapping of Forest degradation and Biodiversity conservation –Mapping of wetlands; Mapping of Site selection for waste disposal.

Unit IV Applications of Remote Sensing and GIS: (20 Hrs.)

Mapping of Groundwater potential zones–Contamination of surface and ground water quality; Watershed Management-Eutrophication and its impacts–Coastal and marine pollution– Coastal dynamics. Mapping of Air pollutants due to Industrial activities.

Unit V Applications of Remote Sensing and GIS for Natural Disaster Assessment: (20 Hrs.)

Floods–Droughts–Landslides–Earthquakes–Volcanic eruptions–Desertification.

B. Topics for Self-study:

- **GIS in EIA** (https://www.tandfonline.com/doi/pdf/10.1080/07349165.1996.972591)
- **Environmental Planning, Design, and GIS** (environmentalscience.org/environmental-planning-design-gis)
- **Land Surface Temperature** (https://earthobservatory.nasa.gov/global-maps/MOD_LSTD_M)
- **Satellite remote sensing of water turbidity** (http://hydrologie.org/hsj/250/hysj_25_04_0407.pdf)

C. Text Books

1. Lillesand, T.M. and P.W. Kiefer, Remote Sensing and Image Interpretation 3rd Ed. (2007). John Wiley and Sons, New York.
2. Chang KT, Introduction to Geographic Information System (2002). McGraw Hill, Boston.
3. Richardson BF Jr (Ed.), Introduction to Remote Sensing of the Environment (1978). Kendall/Hunt, Dubuque, Iowa.

D. Reference Books

1. Reddy MA. Text book of Remote Sensing and GIS (2003). BS Publications Hyderabad.
2. Panda BC. Remote Sensing Principles and Application (2005). Viva Books Private Limited, New Delhi.
3. Singh S, Geomorphology and Remote Sensing in Environmental Management (1992). Scientific Publishers, Jodhpur.
4. Pirazizy AA, Environmental Geography and Natural Hazards (1992). Concept Publishing Company, New Delhi.
5. Sabins FF, Remote Sensing Principles and Interpretation (1978). Freeman, San Francisco.

3. Specific Learning Outcomes:

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Fundamentals of Remote Sensing**		
1.1	Energy sources and radiation principles–Electromagnetic spectrum: Processes and elements of Electromagnetic Remote Sensing	Explain electromagnetic radiation principles in the application of remote sensing	K2
1.2	Interaction of electromagnetic energy with Earth's atmosphere and surface features – Spectral reflectance curve of vegetation, soil and water–	Examine the association between the electromagnetic energy with Earth's atmosphere and surface features	K4
1.3	Types of satellites– Sensor resolution: Spatial, spectral, temporal and radiometric.	Compare the different satellite imagery resolution	K2
1.4	Fundamentals of image interpretation techniques	Relate the basic elements are shape, size, pattern, tone, texture, shadows, location, association and resolution	K3
Unit II	**Principles of Geographic Information System (GIS)**		
2.1	Concepts and Components of GIS – Hardware, software and organizational Context-Data– (spatial and non-spatial)–Maps (types of maps)–Projection (types of projection)	Explain desirable requirement of hardware and software for a GIS technique process	K2
2.2	Data input (digitizer- scanner-editing) Raster and vector data structure- analysis using raster and vector data- retrieval, reclassification, overlaying, buffering-Data output.	Apply the general procedure GIS Raster and vector data analysis in software	K3
Unit III	**Applications of Remote Sensing and GIS**		
3.1	Land use/land cover Mapping; Basic concept and classification and Land use change detection mapping.	Elaborate GIS Technique Land use Land cover plan can be determined by analyzing satellite and aerial imagery	K6
3.2	Mapping of soil erosion prone areas – Mapping of Forest degradation and Biodiversity conservation –Mapping of wetlands; Mapping of Site selection for waste disposal.	Apply the general procedure for satellite image classification technique and mapping	K3
Unit IV	**Applications of Remote Sensing and GIS**		
4.1	Mapping of Groundwater potential zones–Contamination of surface and ground water quality	Illustrate BIS standard for Groundwater and Surface water specification	K3

4.2	Watershed Management-Eutrophication and its impacts– Coastal and marine pollution– Coastal dynamics. Mapping of Air pollutants due to Industrial activities	Apply the general procedure for satellite image classification technique and mapping	K3
Unit V	**Applications of Remote Sensing and GIS for Natural Disaster Assessment**		
5.1	Floods – Droughts – Landslides – Earthquakes – Volcanic eruptions– Desertification.	Apply the general procedure for satellite image classification technique and mapping	K3

4. Mapping Scheme (POs, PSOs and COs)

P20ES3:4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	-	-	-	-	-	-	-	-	-	M	-	-	-
CO2	-	-	-	-	-	-	-	-	-	M	-	-	-
CO3	H	L	H	H	H	H	-	-	-	H	-	-	H
CO4	H	-	-	M	M	H	-	L	-	H	H	-	H
CO5	M	M	H	M	-	H	-	L	-	H	-	H	L
CO6	M	H	M	M	M	H	-	L	-	H	H	-	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Course Coordinator: Dr.D.J.Anand Karunakaran

Core Practical V: AIR POLLUTION AND ITS CONTROL ENGINEERING AND GIS APPLICATIONS

Semester: IV **Code: P20ES4P5**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Describe the principles of sampling and analytical techniques of air Pollution/noise pollution.	**K2**	**I**
CO2	Conduct air pollution / noise pollution sampling and analysis	**K2**	**II**
CO3	Interpret the results	**K4**	**III**
CO4	Relate meteorological parameters with air pollution	**K6**	**III**
CO5	Design the air pollution control devices.	**K6**	**IV**
CO6	Create GIS maps of air / noise pollution.	**K6**	**V**

2.A. Syllabus

Unit I Air analysis: (15 Hrs.)

Particulates: Estimation of PM_{10} in the ambient air; Gaseous Contaminants: Estimation of SO_2, H_2S, NO_X in the ambient air; Vehicular pollution - Emission check.

Unit II Air analysis: (20 Hrs.)

Calculation and Designing of Settling chambers; Calculation and Designing of Cyclones; Calculation and Designing of Electrostatic Precipitator; Fabric filters.

Unit III Air analysis: (10 Hrs.)

Temperature, Humidity; Preparation of wind roses; Determination of Atmospheric Stability – Pasquill–Turner Method.

Unit IV Noise Monitoring: (10 Hrs.)

Ambient noise levels and L_{eq} calculation using sound level meter.

Unit V Application of GIS: (20 Hrs.)

Preparation of Air Quality Index map, Preparation of Noise pollution map at different locations, mapping of meteorological parameters (wind rose, stability).

C. Text Books

1. Trivedy RK, Goel PK and Trisal L, Practical Methods in ecology and Environmental Sciences, Environmental Publications (1987). Karad.
2. Margesin R and Schinner F, Manual of Soil Analysis–Monitoring and Assessing Bioremediation (2005). Springer–Verlag, Berlin, Heidelberg.

D. Reference Books

1. Lodge JP, Methods of Air Sampling and Analysis (1988). Inter Society Committee Publication.
2 . Peavy HS, Rowe D and Tchobanoglous G, Environmental Engineering (2017). Mc Graw Hill Education. ISBN: 9789351340263.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Air analysis**		
1.1	Particulates: Estimation of PM_{10} in the ambient air;	Operate the air pollution sampler	K3
		Estimate the concentration of PM_{10}& Interpret the results	K5
1.2	Gaseous Contaminants: Estimation of SO_2, H_2S, NO_X in the ambient air;	Operate the air pollution sampler	K3
		Estimate the concentration of SO_2, H_2S, NO_X in the ambient air& Interpret the results	K5
1.3	Vehicular pollution- Emission check.	Evaluate the air pollution emissions from vehicles	K6
Unit II	**Air analysis**		
2.1	Calculation and Designing of Settling chambers; Calculation and Designing of Cyclones; Calculation and Designing of Electrostatic Precipitator; Fabric filters.	Design the air pollution control devices	K5
Unit III	**Air analysis**		
3.1	Temperature, Humidity;	Measure the temperature and humidity	K6
3.2	Preparation of wind roses;	Prepare wind roses from the wind data	K5
3.3	Determination of Atmospheric Stability– Pasquill– Turner Method.	Identify the stability condition of the atmosphere	K4
Unit	**Noise Monitoring**		
4.1	Ambient noise levels and L_{eq} calculation using sound level meter.	Assess the noise pollution	K6
Unit V	**Application of GIS**		
5.1	Preparation of Air Quality Index map,	Prepare GIS Map with GIS software of air quality index	K5
5.2	Preparation of Noise pollution map at different locations,	Prepare GIS Map with GIS software of Noise pollution	K5
5.3	Mapping of meteorological parameters (wind rose, stability).	Prepare GIS Map with GIS software of wind roses, and stability	K5

4. Mapping Scheme (POs, PSOs and COs)

P20ES4P5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	-	L	H	-	-	-	-	-	H	L	L	-
CO2	H	L	L	H	L	-	L	L	L	H	H	H	M
CO3	H	L	L	-	H	M	L	L	L	H	H	H	M
CO4	H	H	L	M	H	M	M	L	L	H	M	M	L
CO5	M	-	L	M	H	H	M	L	L	H	M	L	H
CO6	H	L	L	H	H	H	M	L	L	H	M	L	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Pre-semester and End-semester Examinations (ESE)
3. Reports, Observation Register, Record Note Books and Viva-voce

Indirect

1. Overall performance assessment, Discussions and co-curricular activities

Course Coordinator: Dr.C.Ravichandran

Elective V: INTERNSHIP AND FIELD WORK

Semester: IV **Code: P20ES4F1**
Credits: 4 **Hours/Week: 5**

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Conduct Environmental Audit for residences, institutions and industries.	**K3**	**I**
CO2	Explain the environmental pollution and control practices in various industries.	**K2**	**II**
CO3	Appraise and report the selected ecosystems and the ecological principles.	**K5**	**III**
CO4	Prepare Biodiversity Register.	**K6**	**IV**
CO5	Prepare Participatory Rural Appraisal.	**K6**	**V**
CO6	Create Environmental Education Strategies and executing them.	**K6**	**VI**

2. Syllabus

Unit I Internship

Minimum duration of 15 days in any one of the industries (Industries/Waste Management Facility/Environmental Laboratories/Consultancies/NGOs etc.).

Unit II Domestic and Institutional Environmental Audit:

Importance, objectives, methodology, assessment, result and inference & conservation measures of water audit, energy audit waste audit and domestic carbon footprint. Conduct of water audit, energy audit and waste audit at home. Conduct of domestic carbon footprint. Conduct of water audit, energy audit and waste audit in campus.

Unit III Visits to industries/environmental management facilities/environmental concerns and Eco-Tour

Visits to the industries/environmental management facilities/environmental concerns mentioned in **Appendix I**

a. Types of industries
b. Industry and environment

Eco-Tour:

Visit to different ecosystems as in **Appendix II**

1. Conservation of Biodiversity – Visit and description of in-situ conservation areas
2. Conservation of Biodiversity – Visit and description of ex-situ conservation areas
3. Natural ecosystem biodiversity – Montane ecosystem - visit and description
4. Natural ecosystem biodiversity – Littoral forests- visit and description
5. Diversity of artificial ecosystems – Visit, description, impacts and mitigation

Unit IV Preparation of People's Biodiversity Register & Participatory Rural Appraisal:

Peoples Biodiversity Register - Concept and importance; strategies.
Participatory Rural Appraisal - Concept and importance; steps.

Conduct Peoples Biodiversity Register & Participatory Rural Appraisal

Unit V Environmental Education:

Importance and objectives of environmental education; Forms of Environmental Education – Formal, non-formal; Guidelines of contents for early childhood, higher education, adult and general public. Practice: Planning, preparation and implementation of environmental awareness for rural /urban school children/public

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Domestic Environmental Audit**		
1.1	Domestic Environmental Audit: Importance, objectives, and methodology, assessment, result and inference & conservation measures of water audit, energy audit waste audit and domestic carbon footprint.	Plan a domestic environmental audit including water, waste and energy components	K4
1.2	Conduct of water audit, energy audit and waste audit at home.	Perform water audit and waste audit	K5
1.3	Conduct of domestic carbon footprint.	Conduct a domestic carbon footprint.	K5
Unit II	**Institutional Environmental Audit**		
2.1	Institutional Environmental Audit: Conduct of water audit, energy audit and waste audit in campus.	Plan an institutional environmental audit including water, waste and energy components	K4
Unit III	**Visits to industries/environmental management facilities/environmental concerns**		
3.1	Visits to industries/environmental management facilities/environmental concerns: Introduction to industries a. Types of industries b. Industry and environment	Explain various industrial processes and their environment-friendly practices	K2
Unit IV	**Eco-Tour**		
4.1	Visit to different ecosystems as in **Appendix II** 1. Conservation of Biodiversity – Visit and description of in-situ conservation areas 2. Conservation of Biodiversity – Visit and description of ex-situ conservation areas 3. Natural ecosystem biodiversity – Montane ecosystem - visit and description 4. Natural ecosystem biodiversity – Littoral forests- visit and description	Demonstrate the conservation strategies suitable for various ecosystems	K3

	5. Diversity of artificial ecosystems – Visit, description, impacts and mitigation		
Unit V	**Preparation of People's Biodiversity Register & Participatory Rural Appraisal**		
5.1	Preparation of People's Biodiversity Register & Participatory Rural Appraisal: Peoples Biodiversity Register - Concept and importance; strategies. Participatory Rural Appraisal - Concept and importance; steps.	Prepare a People's Biodiversity Register & Participatory Rural Appraisal	K6
5.2	Conduct Peoples Biodiversity Register & Participatory Rural Appraisal	Conduct Peoples Biodiversity Register & Participatory Rural Appraisal	K5
Unit 6	**Environmental Education**		
6.1	Environmental Education: Importance and objectives of environmental education; Forms of Environmental Education – Formal, non-formal;	Devise an environmental education programme	K6
6.2	Guidelines of contents for early childhood, higher education, adult and general public.	Prepare guidelines of contents for early childhood, higher education, adult and general public.	K6
6.3	Practice: Planning, preparation and implementation of environmental awareness for rural /urban school children/public	Role-play an environmental awareness programme	K6

5. Course Assessment Method

Direct

1. Reports, Observation Register, Record Note Books and Viva-voce

Indirect

1. Overall performance assessment, Discussions and co-curricular activities

Course Coordinator: Respective Guides

Extra Credit Course: ENVIRONMENTAL AUDIT

Semester: 3 **Code: PXES3:1**
Credits: 2

1. Course Outcomes

On completion of the course, the students will be able to:

CO	Outcomes	K-level	Unit
CO1	Identify the fundamental elements and Needs for Environmental Audit at Local and Global Levels.	K1	I
CO2	Assess and describe the Natural Resources – Air, Water, Soil, Space, Biodiversity (Greenbelt).	K5	II
CO3	List out the Facility Infrastructure, Energy, Transport, Aesthetics Internal and External sources.	K1	II
CO4	Compute the Process Environment, Economic management and Risk Assessment.	K3	III
CO5	Analyze the tools for auditing, Legal Implications and Environmental Education.	K5	IV
CO6	Categorize the Site Audit and Data Collection.	K4	V
CO7	Demonstrate Environmental Statement and Environmental Management Plant – Case Studies	K2	V

2.A. Syllabus

Unit I Introduction

Fundamentals – Definition, aims, principle elements (External and Internal audit), Types and Scope (Industrial and Institutions). Needs for Environmental Audit at local and global levels.

Unit II Resource Audit

Resource Assessment: Natural Resources – Air, Water, Soil, Space, Biodiversity (Greenbelt). Facility Infrastructure, Energy, Transport, Aesthetics – Internal and External.

Unit III Risk Assessment

Process Environment, Economic management and Risk Assessment – Process environment: Process efficiency, pollution, waste generations and recycling. Economic management – process cost analysis, Environmental protection cost analysis. Lifecycle cost analysis. Risk Assessment – types of risk, expected value, assessment of the degree of risk.

Unit IV Environmental Audit

Pre-Audit requisites: Tools for auditing: Auditors (Internal and External): Connected with audit, Policy impact matrix. Legal implications (Environmental Legislation – Gazette Notification of Environmental Audit, 1992). Geographic database. Statutory agencies. Community awareness and involvement. Environmental education.

Unit V Environmental Management Plan

Audit processing (Site audit and Post Audit processes): Site Audit: Primary and Secondary data collection using appropriate methods and establishment of database. Drafting of Environmental Statement. Environmental Management Plan – case Study.

C. Text Books

1. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case Study (1980). Hemisphere, Washington.
2. Frankel M, The Social Audit Pollution Handbook: How to Assess Environmental and Workplace Pollution (1978). Palgrave Macmillan UK. ISBN: 9780333216477.
3. Dewulf J and Van Langenhove H, Renewables-based technology: sustainability assessment (2006). Wiley and Sons. ISBN: 9780470022412.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Fundamentals – Definition, aims, principle elements (External and Internal audit), Types and Scope (Industrial and Institutions). Needs for Environmental Audit at local and global levels.	Learn and Identify the Fundamental elements, types, scope and Needs for Environmental Audit at local and Global Levels	K3
Unit II	**Resource Audit**		
2.1	Resource Assessment: Natural Resources – Air, Water, Soil, Space, Biodiversity (Greenbelt).	Assess the Natural Resources Such as Air, Water, Soil, Space Biodiversity (Greenbelt)	K2
2.2	Facility Infrastructure, Energy, Transport, Aesthetics – Internal and External.	List out the facility Infrastructure, Energy, Transport Aesthetics-Internal and External sources	K3
Unit III	**Risk Assessment**		
3.1	Process Environment, Economic management and Risk Assessment – Process environment: Process efficiency, pollution, waste generations and recycling.	Able to Compute the Process Environment, Economic management and Risk Assessment	K3
3.2	Economic management – process cost analysis, Environmental protection cost analysis. Lifecycle cost analysis.	Able to list out and analyze the process cost analysis, Environmental protection cost analysis and Life cycle analysis.	K4
3.3	Risk Assessment–types of risk, expected value, assessment of the degree of risk.	Identify the types of risks, estimate the expected value, assess the degree of risks	K5
Unit IV	**Environmental Audit**		
4.1	Pre-Audit requisites: Tools for auditing: Auditors (Internal and External): Connected with audit, Policy impact matrix. Legal implications (Environmental Legislation – Gazette Notification of Environmental Audit, 1992). Geographic database. Statutory agencies. Community awareness and involvement. Environmental education.	Analyze the tools for auditing, Legal Implications and Environmental Education.	K6

Unit V	Environmental Management Plan		
5.1	Audit processing (Site audit And Post Audit processes): Site Audit: Primary and Secondary data collection using appropriate methods and establishment of database. Drafting of Environmental Statement. Environmental Management Plan – case Study.	Discriminate the Pre-Audit and Post audit Processing of Environmental Audit. Collect the primary and secondary data using appropriate methods and establish with database. Prepare the Environmental Statement and Environmental Management Plant. Students can be able to compile all the data and prepare a report for the Case studies Categorize the Site Audit and Data Collection.	K6

4. Mapping Scheme (POs, PSOs and COs)

PXES3:1	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	-	-	-	-	-	M-	-	H	M	-	L
CO2	H	M	-	H	L	-	-	L	L	H	L	-	-
CO3	H	H	M	-	-	L	-	-	-	H	-	-	L
CO4	H	L	L	L	M	L	-	H	L	H	M	M	L
CO5	H	H	M	L	-	L	M	L	L	H	L	-	L
CO6	H	H	M	L	M	L	M	-	L	H	L	-	L
CO7	H	H	M	M	-	-L	L	-	M	H	L	-	-

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Extra Credit Course: ENVIRONMENTAL ECONOMICS

Semester: 3 **Code: PXES3:2**
Credits: 2

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Define and Explain the Economics Paradigms, Perspectives from economics and ecology, Total economic, option and existence value.	**K2**	**I**
CO2	Relates the Environmental and resource economics, Explain Consumer choice theory and evaluation of market value, Measure depreciation of natural capital.	**K6**	**II**
CO3	Observe the Sustainable Development Goals (SDGs); Measuring Sustainable Development, Cost-Benefit Analysis and Green Economy, Green manufacturing, Green Finance and Green Tourism and Investing in Natural Capital.	**K2**	**III**
CO4	Describe the Ecological Indicators and footprint, global and regional trends. Illustrate the economic instruments- Taxation, Charges and subsidies, Marketable pollution permits.	**K3**	**IV**
CO5	Point out the Emission Standards and Effluent Charges, Transferable Pollution Credits, Voluntary Actions and Agreements.	**K4**	**IV**
CO6	Evaluate the Triple Bottom Line Accounting, Genuine Progress Indicator, GDP per capita Gross National Product, Gini coefficient and Corruption Perceptions Index.	**K6**	**V**

2.A. Syllabus

Unit I Introduction:

Economic paradigms and the rise of environmentalism; Economy and the Environment Interactions; Perspectives from economics and ecology; carrying capacity; Economics of bio-diversity; Total economic value, Option value and Existence value.

Unit II Resource Economics:

Environmental and Resource Economics; Resource use in society; Consumer choice theory; The market model of environmental values; Monopoly; Public goods; Measure depreciation of natural capital.

Unit III Sustainable Development:

Sustainable Development Goals (SDGs); Measuring Sustainable Development; Cost-Benefit Analysis; Green Economy; Green manufacturing, Green Finance and Green Tourism; Investing in Natural Capital.

Unit IV Pollution and Economy:

Ecological Indicators and footprint- global and regional trends; Economic instruments-Taxation, Charges and subsidies; Marketable pollution permits; Emission Standards and Effluent Charges; Transferable Pollution Credits; Voluntary Actions and Agreements.

Unit V Economic Indicators:

Triple Bottom Line Accounting; Input-output analysis; Genuine Progress Indicator; GDP per capita; Gross National Product; Gini coefficient; Corruption Perceptions Index.

C. Text Books

1. Kolstad CD, Environmental Economics 2nd Ed. (2011). Oxford University Press.
2. Field B and Field MK, Environmental Economics: An Introduction (2012). McGraw Hill.
3. Hussen A, Principles of Environmental Economics and Sustainability – An integrated economic and ecological approach 3rd Ed. (2013). Routledge London and New York.

D. Reference Books

1. Cato MS, Environment and Economy Routledge-Introduction to Environment Series (2011). Routledge London and New York.
2. Baumol, WJ. and Oates WE, The Theory of Environmental Policy (1988). Cambridge University Press.
3. Fisher AC, Resource and Environmental Economics (1981). Cambridge University Press.
4. Nick H and Jason FS, Ben White Environmental Economics (1997) Oxford University Press, New York.
5. Tom T and Lynne L, Environmental & Natural Resource Economics (2009). Prentice Hall.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Economic paradigms and the rise of environmentalism; Economy and the Environment Interactions; Perspectives from economics and ecology; carrying capacity; Economics of bio-diversity; Total economic value, Option value and Existence value.	Learn and Identify the Economic paradigms and Environment perspectives from economics and ecology.	**K3**
Unit II	**Resource Economics**		
2.1	Environmental and Resource Economics; Resource use in society; Consumer choice theory; The market model of environmental values; Monopoly; Public goods; Measure depreciation of natural capital.	Distinguish between the environmental and resource economics. Explain consumer choice theory. Select the market model of environmental values, Monopoly, Public goods and measure depreciation of natural capital.	**K4**
Unit III	**Sustainable Development**		
3.1	Sustainable Development Goals (SDGs); Measuring Sustainable Development; Cost-Benefit Analysis; Green Economy; Green manufacturing, Green Finance and Green Tourism; Investing in Natural Capital.	Observe the Sustainable Development Goals. Assess and analyze the cost benefit analysis. Classify the Green Economy, Green Manufacturing, Green Finance, Green Tourism and Investing in Natural Capital	**K4**
Unit IV	**Pollution and Economy**		
4.1	Ecological Indicators and footprint- global and regional trends; Economic instruments-	Identify the Ecological Indicators and foot print.	

	Taxation, Charges and subsidies; Marketable pollution permits; Emission Standards and Effluent Charges; Transferable Pollution Credits; Voluntary Actions and Agreements.	Illustrate the Economic Instruments, Taxation, Charges and subsidies. Point out the Emission Standards and Effluent Charges, Transferable Pollution Credits, Voluntary Actions and Agreements.	**K4**
Unit V	**Economic Indicators**		
5.1	Triple Bottom Line Accounting; Input-output analysis; Genuine Progress Indicator; GDP per capita; Gross National Product; Gini coefficient; Corruption Perceptions Index.	Describe the triple bottom line accounting. Compile the Genuine Progress Indicator, GDP per capita, Gross National Product and Gini Coefficient. Explain Corruption Perceptions Index.	**K6**

4. Mapping Scheme (POs, PSOs and COs)

PXES3:2	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	-	M	-	H	-	M-	-	H	M	-	L
CO2	H	M	-	H	L	-	-	L	L	H	M	-	-
CO3	H	H	M	-	-	M	H	-	-	H	-	-	M
CO4	H	M	L	L	M	L	-	H	L	H	M	M	L
CO5	H	H	M	L	-	L	M	L	L	H	L	-	M
CO6	H	H	M	L	M	L	M	-	L	H	L	-	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Extra Credit Course: OCCUPATIONAL HEALTH AND INDUSTRIAL SAFETY

Semester: 3 **Code: PXES3:3**
Credits: 2

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Define and Explain the Safety Parameters, Safety Regulations and Factories Act.	**K2**	**I**
CO2	Relates the work place effect, Work Physiology and Performance evaluation of systems with man and environment.	**K6**	**II**
CO3	Match the Occupational diseases (Physical, Chemical, and Biological) and its prevention, control.	**K5**	**III**
CO4	Evaluate the Industrial Safety & Management System	**K5**	**III & IV**
CO5	Discuss on Industrial Safety Standards and Regulations	**K6**	**IV**
CO6	Discuss the Concepts of safety management systems, International safety certification, OHSA'S compliance.	**K6**	**V**

2.A. Syllabus

Unit I Introduction

Introduction: Parameters of safety – Policy factors affecting the conditions of occupational and industrial safety –safety Regulations. Factories Act

Unit II Working Environment

Principles of Ergonomics: Role of ergonomics in designing work place, effects of work environment – light–ventilation-vibration – noise. Work physiology and its relevance to safety. Performance evaluation of systems involving man and environment.

Unit III Occupational Health and Safety

Occupational health and hazards – physical –chemical – biological hazards, Occupational diseases-prevention and control, Health protection measures for workers – health education – medical first-aid. Management of medical emergencies.

Unit IV Industrial Safety Management Techniques

Industrial safety standards. Accidents- definition –frequency rate-prevention and control. Work study – work measurement – measurement of skills, safety cost and expenses. Principles of functions and safety management.

Unit V Safety Management System

Concepts of safety management systems. International safety certification. OHSAS compliance.

C. Text Books

1. Diberardinis LJ, Handbook of Occupational Safety and Health (1998). John Wiley, New York.
2. Peterson RD and Cohen JJ, The complete guide to OSHA Compliance (1997). Lewis publishers, New York.
3. Scott RM, Basic Concepts of Industrial Hygiene (1997). Lewis publishers, New York.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1	Introduction: Parameters of safety – Policy factors affecting the conditions of occupational and industrial safety – safety Regulations. Factories Act.	Learn and Identify the factors affecting the conditions of occupational and industrial safety, safety regulations and Factory Act	K3
Unit II	**Working Environment**		
2	Principles of Ergonomics: Role of ergonomics in designing work place, effects of work environment – light–ventilation-vibration – noise. Work physiology and its relevance to safety. Performance evaluation of systems involving man and environment.	Construct in designing the work place and effects of work environment. Evaluate the system performance between man and Environment.	K6
Unit III	**Occupational Health and Safety**		
3	Occupational Health and Safety: Occupational health and hazards – physical –chemical–biological hazards, Occupational diseases prevention and control, Health protection measures for workers–health education – Medical first-aid. Management of medical emergencies.	Classify the occupational health hazards and health protection measures for workers. Manage the medical first aid medical emergencies	K6
Unit IV	**Industrial Safety Management Techniques**		
4	Industrial Safety Management Techniques: Industrial safety standards. Accidents- definition –frequency rate-prevention and control. Work study – work measurement – measurement of skills, safety cost and expenses. Principles of functions and safety management.	Identify and develop a list of hazards in the occupational health and safety.	K6
Unit V	**Safety Management System**		
5	Safety Management System: Concepts of safety management systems. International safety certification. OHSAS compliance.	Apply developed skill in the safety management technique and be able to compile all the data and prepare a report for international certification and OHSAS compliance.	K6

4. Mapping Scheme (POs, PSOs and COs)

PXES3:3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	-	M	-	H	-	M-	-	H	M	-	L
CO2	H	M	-	H	L	-	-	L	L	H	M	-	-
CO3	H	H	M	-	-	M	H	-	-	H	-	-	M
CO4	H	M	L	L	M	L	-	H	L	H	M	M	L
CO5	H	H	M	L	-	L	M	L	L	H	L	-	M
CO6	H	H	M	L	M	L	M	-	L	H	L	-	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Extra Credit Course: FOREST MANAGEMENT

Semester: 3 **Code: PXES3:4**
Credits: 2

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Define the forest ecology, types of forests, its resources and threats.	**K1**	**I**
CO2	Recognize the social, economic and environmental values of forest resources.	**K1**	**II**
CO3	Identify the threats to forest resources.	**K2**	**III**
CO4	Explain the Role of Afforestation and forest regeneration in absorption of CO_2.	**K2**	**IV**
CO5	Restate the forest policy, legislation and forest management strategies.	**K2**	**V**
CO6	Apply the management strategies towards forest conservation.	**K3**	**V**

2.A. Syllabus

Unit I Introduction

Forest ecology – Forest community concepts; vegetation concepts; productivity nutrient cycling and relations, physiology in stress environments (drought, water logging salinity and alkalinity).

Unit II Forest Resources and Economics

Forest Resources; Timber environment sound forest harvest practices; logging extraction techniques and principles, transportation system, storage and sale; Non – Timber forest Products (NTFPs) definition and scope; (gums, oil seeds nuts, bamboos, medicinal plants). Forest economics – fundamental principles, cost-benefit analyses; estimation of demand and supply; analysis.

Unit III Forest Resource Conservation

Forest- threats and Protective Measures: Forest Fire (cause, effects -economic and environmental costs and control measures). Human – animal conflicts (encroachment, poaching, grazing, fencing, theft, shifting cultivation and control). Grazing and browsing (Rotational and controlled grazing, different methods of control against animals) Effect of wild animals on forest regeneration, Role of Afforestation and forest regeneration in absorption of CO_2.

Unit IV Forest policy and Legislation

Indian forest policy 1990. National Forest Policy 1998 – Wildlife Protection Act 1972 and their amendments. Forest Conservation Act 1980.Application of Indian penal Code to forest international timber law. Scope and objective s of forest inventory.

Unit V Forest Resource Management

Forest management and management systems, objective and principles; techniques; stand structure and dynamics, sustained yield relation, rotation, normal forest, growing stock; regulation of yield management of forest plantations, commercial forests, forest cover monitoring. Agroforestry, Social Forestry, Joint Forest Management.

C. Text Books

1. Puri GS, Gupta RK, Meher-Homji VM and Puri, Forest Ecology (1989). Oxford and IBH publishing Co., Pvt. Ltd, New Delhi.
2. FSI, State of Forest Report (1997). Forest survey of India, Ministry of Environment and Forests, Dehradun.
3. Gadgil M and Guha R, Ecology and Equity: the use and abuse of nature in contemporary India (1995). Penguin books, New Delhi.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Forest ecology – Forest community concepts; vegetation concepts	Recall the forest type, community and vegetation	K1
1.2	productivity nutrient cycling and relations	Compare productivity and nutrient cycle	K4
1.3	physiology in stress environments (drought, water logging salinity and alkalinity)	Explain various stress of the environment	K2
Unit II	**Forest Resources and Economics**		
2.1	Forest Resources and Economics: Forest Resources; Timber environment sound forest harvest practices;	Recall various resources of the forest	K1
2.2	logging extraction techniques and principles,	Explain extraction techniques and principles of timbers	K2
	transportation system, storage and sale;	Illustrate the transportation system, storage and sale of the timbers	
2.3	Non –Timber forest Products (NTFPs) definition and scope; (gums, oil seeds nuts, bamboos, medicinal plants).	Recall Definition and scope of non-timber forest products	K1
2.4	Forest economics –fundamental principles, cost-benefit analyses; estimation of demand and supply; analysis.	Discuss fundamental principles, cost benefit analysis	K6
Unit III	**Forest Resource Conservation**		
3.1	Forest- threats and Protective Measures: Forest Fire (cause, effects -economic and environmental costs and control measures).	Explain causes and effects forest fire	K2
3.2	Human animal conflicts (encroachment, poaching, grazing, fencing, theft, shifting cultivation and control).	Discuss human animal conflicts	K6
3.3	Grazing and browsing (Rotational and controlled grazing, different methods of control against animals)	Illustrate the difference between grazing and browsing	K2
3.4	Effect of wild animals on forest regeneration, Role of Afforestation and forest regeneration in absorption of CO_2.	Explain forest regeneration	K2
		Illustrate the role afforestation	
		Discuss forest regeneration in absorption of CO_2	K6

Unit IV	Forest policy and Legislation		
4.1	Forest policy and Legislation: Indian forest policy 1990.	Recall Indian forest policy 1990	K1
4.2	National Forest Policy 1998	Explain national forest policy 1998	K2
4.3	Wildlife ProtectionAct1972 and their amendments.	Discuss forest conservation Act 1972 and their amendments	K6
4.4	Forest Conservation Act1980.	Illustrate forest conservation Act 1980	K2
4.5	Application of Indian penal Code to forest international timber law.	Discuss forest international timber law.	K6
4.6	Scope and objectives of forest inventory.	Recall scope and objectives of forest inventory	K1
Unit V	**Forest Resource Management**		
5.1	Forest management and management systems, objective and principles; techniques; stand structure and dynamics, sustained yield relation, rotation, normal forest, growing stock	Explain forest management system	K2
5.2	Regulation of yield management of forest plantations, commercial forests, forest cover monitoring.	Discuss regulation of yield management of forest plantation	K6
5.3	Agroforestry, Social Forestry, Joint Forest Management.	illustrate joint forest management	K2

4. Mapping Scheme (POs, PSOs and COs)

PXES3:4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	-	-	-	L	-	-	-	H	M	-	L
CO2	H	H	-	M	L	-	L	-	L	H	M	-	-
CO3	H	H	M	-	-	L	-	-	-	H	-	-	L
CO4	H	H	M	L	L	L	-	L	L	H	M	M	L
CO5	H	H	M	L	-	L	L	L	L	H	L	-	L
CO6	H	H	M	L	L	L	L	-	L	H	M	-	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Extra Credit Course: SOLID WASTE MANAGEMENT

Semester: 4 **Code: PXES4:1**
Credits: 2

1. Course Outcomes

On completion of this course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Recognize the types of solid waste (both biodegradable and non-biodegradable).	**K2**	**I**
CO2	Apply the waste management technologies to solve environmental problems.	**K5**	**II**
CO3	Explain various waste disposal methods	**K2**	**II**
CO4	Explain methods of managing hazardous wastes.	**K2**	**III**
CO5	Discuss about management of biomedical and E-wastes.	**K5**	**IV**
CO6	Appraise the energy-producing technologies from biowastes.	**K4**	**V**

2.A. Syllabus

Unit I Introduction:

Wastes – Introduction, sources, characteristics, composition, classification, waste generated per capita Global scenario of wastes - Waste collection, Storage and segregation - Transportation and disposal methods - Sanitary land filling techniques.

Unit II Municipal Solid Waste Management:

Municipal solid waste – Sources, types, collection and transportation, Waste processing and resource recovery (typical material recovery facility operation (TMRF)) - Reuse and recycling of paper, glass and rubber - Disposal methods*:* Incineration, Pyrolysis, composting, sanitary landfills and aerobic and anaerobic digestion.

Unit III Hazardous Waste Management:

Hazardous waste - Introduction, characteristics - Classification of hazardous waste (Industrial, hospital and domestic) - Handling of hazardous solid wastes (segregation, recovery of hazardous waste substances) - Hazardous waste disposal techniques - Radioactive wastes: Sources, pollution, types of radioactive waste and its control and management.

Unit IV Biomedical, Plastic & e-waste Management:

Biomedical wastes: Sources, types of biomedical wastes – Impacts of biomedical wastes on environment Control measures of biomedical wastes - Plastic wastes: Sources, Facts & figures of plastic waste scenarios in National & International – Effect of plastic wastes on environment – Control measures of plastic wastes. E-wastes: Sources, types of e wastes – Impacts of e-wastes in environment - Control measures of e-wastes.

Unit V Energy Recovery from Wastes:

Vermicomposting, mushroom sheds, fly ash bricks, biogas, and Bio -electro chemical systems – Microbial electrolysis cell – Microbial fuel cell - Production of methane, Hydrogen peroxide, ethanol, electricity.

C. Text Books

1. Hester RE and Harrison RM, Electronic Waste Management, Design Analysis and Application (2009). RSC Publishing, UK.
2. Saling J, Radioactive Waste Management (2001). CRC Press, FL, USA.
3. Pitchel J, Waste Management Practices- Municipal, Hazardous, and Industrial (2005). Taylor & Francis Group, LLC.
4. Lagrega MD, Buckingham PL and Evans JV, Hazardous Waste Management (2001). McGraw Hill Int. Ed. New York.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Introduction to waste, sources, characteristics, composition, classification, waste generated per capita Global scenario of wastes	List the sources and characteristics	K1
		Categories the composition and classification	K4
		Explain the Global scenario of wastes.	K5
1.2	Waste collection, Storage and segregation	Explain the collection, storage and segregation of waste	K5
1.3	Transportation and disposal methods - Sanitary land filling techniques.	List the Transportation and disposal methods	K1
		Recommend sanitary land filling techniques	K5
Unit II	**Municipal Solid Waste Management**		
2.1	Municipal solid waste – Sources, types, collection and transportation	Define MSW	K1
		List the sources of solid waste	K1
		Categories the types of solid waste	K4
		Discuss the collection and transportation of solid waste	K5
2.2	Waste processing and resource recovery (typical material recovery facility operation (TMRF)) – Reuse and recycling of paper, glass and rubber	Explain the waste and resource recovery processing	K5
		Formulate the techniques of recycling of waste.	K6
		Compare the reuse and recycling techniques	K5
2.3	Disposal methods*:* Incineration, Pyrolysis, composting, sanitary landfills and aerobic and anaerobic digestion.	Explain the incineration methods	K5
		Illustrate the incineration methods	K2
		Discuss the composting methods	K5
		Design the sanitary landfills	K5
		Recommend the disposal methods	K6
		Formulate the methods aerobic and anaerobic digestion	K6

Unit III	**Hazardous Waste Management**		
3.1	Hazardous waste - Introduction, characteristics - Classification of hazardous waste (Industrial, hospital and domestic)	Categorise the classification of HW	K4
		Define industrial, hospital and domestic waste.	K1
		Categorise industrial, hospital and domestic waste.	K4
		Discuss industrial, hospital and domestic waste.	K6
3.2	Handling of hazardous solid wastes (segregation, recovery of hazardous waste substances) - Hazardous waste disposal techniques	Define segregation	K1
		Explain handling of hazardous waste	K5
		Discuss the hazardous waste disposal techniques	K6
3.3	Radioactive wastes: Sources, pollution, types of radioactive waste and its control and management.	Define radioactive wastes	K1
		Explain the radioactive pollution	K5
		Categories the types of radioactive waste	K4
		Discuss the radioactive waste control and management	K6
Unit IV	**Biomedical, Plastic & e-waste Management**		
4.1	Biomedical wastes: Sources, types of biomedical wastes – Impacts of biomedical wastes on environment Control measures of biomedical wastes	Define biomedical wastes	K1
		Categories the types of biomedical wastes	K4
		Discuss the impacts and control measures of biomedical.	K6
4.2	Plastic wastes: Sources, Facts & figures of plastic waste scenarios in National & International – Effect of plastic wastes on environment – Control measures of plastic wastes.	Define plastic wastes	K1
		List the sources of plastic wastes	K1
		Summarize facts and figures of plastic waste scenarios in National & International	K2
		Explain the effects of plastic wastes on environment	K5
		Discuss the control measures of plastic wastes	K6
4.3	E-wastes: Sources, types of e wastes – Impacts of e-wastes in environment - Control measures of e-wastes.	List the sources of plastic wastes	K1
		Categories types of e-waste	K1
		Explain the impacts of e-wastes in environment	K5

		Discuss the control measures of e-wastes	K6
Unit V	**Energy Recovery from Wastes**		
5.1	Energy Recovery from Wastes - Vermicomposting, mushroom sheds, flyash bricks, biogas,	Estimate the energy recovery from wastes	K5
		Explain the vermicomposting technology	K5
		Outline the mushroom sheds technology	K2
		Elaborate the fly ash bricks technology	K6
		Demonstrate the biogas technology	K2
5.2	Bio-electro chemical systems– Microbial electrolysis cell–	Explain the bio-electro chemical systems	K5
		Discuss the Microbial electrolysis cell	K6
5.3	Microbial fuel cell- Production of methane, Hydrogen peroxide, ethanol, electricity.	Demonstrate microbial fuel cell	K2
		Discuss the production of methane	K6
		Explain the Hydrogen peroxide, ethanol production	K5
		Elaborate the production of electricity	K6

4. Mapping Scheme (POs, PSOs and COs)

PXES4:1	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	-	-	-	L	M-	L	L	L	L	M	L	L	L
CO2	L	L	L	M	M	M	M	L-	L	-	H	L	M
CO3	L	L	L	M	M	M	M	L-	L	-	H	L	M
CO4	-	L	L	M	-	-	L	L	L	L	M	M	M
CO5	-	-	-	M	H	-	M	M	L	-	M	M	M
CO6	L	L	H	M	M	L	L	M	M	L	L	M	M

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Extra Credit Course: GREEN SCIENCE AND TECHNOLOGY

Semester: 4 **Code: PXES4:2**

Credits: 2

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Analyze the interrelationship between people, environment and economy	**K1**	**I**
CO2	Discuss about the green science and technology	**K2**	**II**
CO3	Describe green chemistry concepts.	**K2**	**III**
CO4	Apply the knowledge of green chemistry practices in effective management of wastes.	**K2**	**IV**
CO5	Choose suitable Green techniques / practices in industries / buildings, in production	**K5**	**V**
CO6	waste management, and energy production / conservation.	**K5**	**V**

2.A. Syllabus

Unit I Anthroposphere:

Five spheres of the earth and their interaction and interrelationships. Anthroposphere – Definition, its effects of Anthroposphere on environment. Anthropospheric constructs, anthropospheric flows, anthropospheric conduits. Infrastructure, transportation, the communication revolution, technology and Engineering (Brief description only). Acquisition of Raw materials. Agriculture – the most basic industry. Industries and their classification.

Unit II Green Chemistry:

Twelve principles of green chemistry, and green science and technology. Reasons for Green Chemistry (resource minimization, waste minimization concepts) Yield and atom economy. Green oxidation and photochemical reactions. Microwave and Ultrasound assisted reactions. Important techniques and directions in practicing Green Chemistry.

Unit III Green Synthesis and Reactions:

Feed stocks – biological feed stocks. Green Reagents - Stoichiometric and catalytic reagents. Green solvents and reaction conditions. Green synthesis – case studies. Green catalysts – Use of zeolites, silica, alumina, clay, polymers, cyclodextrin and supported catalysts. Biocatalysts – enzymes.

Unit IV Waste Management:

Waste reduction and minimization - recycling, solvent recovery and recycling. Recovery of water from waste water. Physical methods of waste treatment. Chemical treatment. Thermal treatment, biodegradation and treatment and composting. Preparation of wastes for disposal. Ultimate disposal of wastes, In-situ-treatment.

Unit V Green Energy Technologies and Green Buildings:

Sources of energy in the anthroposphere. Energy devices and conversions. Green technology and energy conversion efficiency. Energy conservation and renewable energy sources (list of sources only). Unrealized potential of lingo -cellulose fuels. Hydrogen. Combined power cycles. Green Composites for buildings: Concepts of Green Composites. Water Utilization in Buildings, Low Energy Approaches to Water Management. Management of Solid Wastes Management of Sullage Water and Sewage. Urban Environment and Green Buildings. Green Cover and Built Environment.

C. Text Books

1. Manahan S, Fundamentals of Environmental Chemistry, 3rd Ed. (2009). CRC press, Taylor and Francis Group, Boca Raton.
2. Manahan S, Environmental Science and Technology-A Sustainable Approach to Green Science and Technology, 2nd Ed. (2011). CRC press, Taylor and Francis Group, Boca Raton.
3. Liu David HF and Liptak BG, Environmental Engineers Handbook 2nd Ed. (1997). Lewis Publishers, Boca Raton.
4. Das AK, Environmental Chemistry with Green Chemistry (2010). Books and Allied (P) Ltd., Kolkata.

D. Reference Books

1. Mohit SP, Green Chemistry (2012). Books International, New Delhi.
2. Sanghi R, Srivastava MM, Green Chemistry–Environment Friendly Alternatives (2009). Narosa Publishing House, New Delhi.
3. Brewer DC, Green My Home: 10 Steps to Lowering Energy Costs and Reducing Your Carbon Footprint (2008). Kaplan Publishing. ISBN: 9781427798411.
4. Jagadish KS and Venkatarama BU, Alternative Building Materials and Technologies (2007). New Age International.
5. TERI, Sustainable Building Design Manual, Vol. 1 and 2 (2004). New Delhi.
6. Koenigs Berger OH, Ingersoll TG, Mayhew A and Szokolay SV, Manual of Tropical Housing and Building (1975). Orient Long man.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Anthroposphere**		
1.1	Five spheres of the earth and their interaction and interrelationships	Explain 5 spheres of the Earth system; & relate how matter and energy change and cycle through the system as the spheres interact	K2
1.2	Anthroposphere – Definition, its effects of Anthroposphere on environment. Anthropospheric constructs, anthropospheric flows, anthropospheric conduits.	Explain separate sphere for human activity and impacts	K2
1.3	Infrastructure, transportation, the communication revolution, technology and Engineering (Brief description only). Acquisition of Raw materials. Agriculture – the most basic industry. Industries and their classification	Relate the Qualitative and quantitative changes in transport and communications of revolutionary proportions:	K3
Unit II	**Green Chemistry**		
2.1	Twelve principles of green chemistry, and green science and technology. Reasons for Green Chemistry (resource minimization, waste minimization concepts) Yield and atom economy. Green oxidation and photochemical reactions.	Explain basic principles of green chemistry	K2
		Illustrate principles comprise instructions to implement new chemical products, new synthesis, and new processes	K2

2.2	Microwave and Ultrasound assisted reactions. Important techniques and directions in practicing Green Chemistry	Distinguish between Conventional and Microwave-assisted irradiation	K4
		Explain heating mechanism of microwave irradiation processes	K2
Unit III	**Green Synthesis and Reactions**		
3.1	Feed stocks–biological feed stocks. Green Reagents-Stoichiometric and catalytic reagents. Green solvents and reaction conditions.	Demonstrate the replacing Stoichiometric reactions with Catalytic cycles	K2
3.2	Green catalysts – Use of zeolites, silica, alumina, clay, polymers, cyclodextrin and supported catalysts. Biocatalysts – enzymes.	Relate role of catalysts in green synthesis of chemicals for sustainable future	K3
Unit IV	**Waste Management**		
4.1	Waste reduction and minimization - recycling, solvent recovery and recycling. Recovery of water from wastewater	Relate recycling technology for solvent waste streams and type of process	K3
4.2	Physical methods of waste treatment. Chemical treatment. Thermal treatment, biodegradation and treatment and composting. Preparation of wastes for disposal. Ultimate disposal of wastes, In-situ-treatment.	classified into different type principal and Preliminary and Primary Wastewater Treatment Processes	K3
Unit V	**Green Energy Technologies and Green Buildings**		
5.1	Sources of energy in the anthroposphere. Energy devices and conversions. Green technology and energy conversion efficiency. Energy conservation and renewable energy sources (list of sources only).	Explain energy conversion efficiency and the ratio between the useful output of an energy conversion	K2
		Relate Energy Conversion Devices and their Efficiency	K3
5.2	Unrealized potential of lingo - cellulose fuels. Hydrogen. Combined power cycles. Green Composites for buildings:	Justify Hydrogen Fuel Cell Technology for the Sustainable Future of Stationary Applications	K5
5.3	Concepts of Green Composites. Water Utilization in Buildings, Low Energy Approaches to Water Management	Apply water efficiency through building design and Establish a water budget for building and implement design that minimize the uses of potable water	K3

5.4	Management of Solid Wastes Management of Sullage Water and Sewage. Urban Environment and Green Buildings. Green Cover and Built Environment.	Recommend - Green buildings are sustainable buildings demanding the water conservation as well as preventing pollution and use reuse of grey water and recycle treated water ensuring potable water use for potable purpose	K5

4. Mapping Scheme (POs, PSOs and COs)

PXES4:2	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	L	M	-	-	H	L	-	-	H	H	H	-	L
CO2	H	-	H	L	H	H	-	H	H	H	-	M	H
CO3	H	-	H	L	M	H	H	H	M	H	-	H	H
CO4	H	-	H	L	M	H	H	H	M	H	H	H	H
CO5	H	-	H	L	M	H	H	H	M	H	H	H	H
CO6	H	-	H	L	M	H	H	H	M	H	H	H	H

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
3. Pre-semester and End-semester Examinations (ESE)
4. Open Book Test

Indirect

1. Student Participation in co-curricular activities
2. Course-end Survey

Extra Credit Course: ECOTOURISM

Semester: 4 **Code: PXES4:3**
Credits: 2

1. Course Outcomes

On completion of the course, the students will be able to:

CO No.	Outcomes	K-level	Unit
CO1	Recognize the importance of ecotourism, its components, impacts and management.	**K1**	**I**
CO2	Relate the ecotourism and sustainability.	**K2**	**II**
CO3	Explain the land, people, flora and fauna and climatic variations	**K2**	**III**
CO4	Identify the environmental issues with tourism.	**K2**	**IV**
CO5	Review the eco certification, ecotels and eco-morals.	**K2**	**V**
CO6	Apply management practices towards sustainable ecotourism.	**K3**	**V**

2.A. Syllabus

Unit I Introduction

Scope and definitions; Objectives of tourism (geographical, social, economic, religious, cultural and environmental); Components of tourism (information services, transport and accommodation).

Unit II Ecotourism and Development

Ecotourism – definition and characteristics features (Ecosystem & biodiversity, support to local economy, conservation of biosphere, learning experience); Goals (social, economic and environmental); criteria (conservation, low impact and green efforts, sustainability, recreation, community involvement and environmental education and interpretation.

Unit III Ecotourism in India

India a land of pluralism: land, people, flora and fauna and climatic variations – biogeographic classification of India (10 regions) – Ecosystem types available (terrestrial and aquatic including coastal mangrove and deep sea) – Contrast from tropics to snow.

Unit IV Impacts of Tourism on Environment

Population growth and carrying capacity leading to environmental pressures – biophysical, socio psychological, resource exploitation, poor management, pollution and environmental disturbances.

Unit V Management of Ecotourism

Development of information services, transport and accommodation – Regulation of funds (for operational facilities and administration) – Equitable management and distribution of resources and waste management – Eco certification, policies and regulations – Ecotels & Eco morals – Sustainable ecotourism.

C. Text Books

1. Bhatia AK, Tourism in India: Its History and Development (1978). Sterling Pub., New Delhi.
2. Bhatia AK, Tourism Developments: Principles & Practices (2002). Sterling Pub., New Delhi.
3. Ratandeep S, Dynamics of Modern Tourism (1998). Kanishka Pub., New Delhi.
4. Praveen S, Hand Book of Modern Tourism (1999). Ammol Pub., New Delhi.

3. Specific Learning Outcomes

Unit & Section	Course Content	Learning Outcomes	Highest Blooms Taxonomic Level of Transaction
Unit I	**Introduction**		
1.1	Scope and definitions; Objectives of tourism (geographical, social, economic, religious, cultural and environmental);	Recall scope and definitions of ecotourism	K1
		Illustrate the objectives of ecotourism	K2
1.2	Components of tourism (information services, transport and accommodation).	Discuss the components of ecotourism	K6
Unit II	**Ecotourism and Development**		
2.1	Ecotourism–definition and characteristics features (Ecosystem & biodiversity, support to local economy, conservation of biosphere, learning experience);	Recall definition of ecotourism	K1
		Illustrate characteristics features of ecosystem	K2
2.2	Goals (social, economic and environmental); criteria (conservation, low impact and green efforts, sustainability, recreation, community involvement and environmental education and interpretation.	Explain social, economic and environmental goal of ecotourism	K2
		Discuss the importance of community involvement and environmental education and interpretation	K6
Unit III	**Ecotourism in India**		
3.1	Ecotourism in India – India a land of pluralism: land, people, flora and fauna and climatic variations	Explain – India land of pluralism	K2
3.2	Biogeographic classification of India (10 regions)	Illustrate biogeographical classifications of India.	K2
3.3	Ecosystem types available (terrestrial and aquatic including coastal mangrove and deep sea) – Contrast from tropics to snow.	Discuss various types of ecosystem	K6
Unit IV	**Impacts of Tourism on Environment**		
4.1	Impacts of tourism on environment: population growth and carrying capacity leading to environmental pressures	Illustrate environmental impacts of ecotourism	K2
4.2	biophysical, socio psychological, resource exploitation, poor management, pollution and environmental disturbances.	Explain pollution and environmental distribution of ecotourism	
Unit V	**Management of Ecotourism**		
5.1	Management of ecotourism: Development of information services, transport and accommodation	Explain the management of ecotourism	K2

5.2	Regulation of funds (for operational facilities and administration)	Discuss management of funds in operational facilities and administration	K6
5.3	Equitable management and distribution of resources and waste management	Illustrate equitable management in ecotourism	K2
5.4	Eco certification, policies and regulations	Explain eco certification, policies and regulations	
5.5	Ecotels & Eco morals– Sustainable ecotourism.	Discuss Ecotels and Eco morals in sustainable ecotourism	K6

4. Mapping Scheme (POs, PSOs and COs)

PXES4:3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	-	-	-	-	-	-	-	H	M	-	L
CO2	H	H	M	M	L	-	L	-	L	H	L	-	-
CO3	H	H	M	-	-	L	-	-	-	H	-	M	L
CO4	H	H	M	M	L	L	-	L	L	H	M	M	L
CO5	H	H	M	L	-	L	L	L	L	H	L	-	L
CO6	H	H	M	L	L	L	L	-	L	H	L	-	L

L: Low; M-Medium; H-High

5. Course Assessment Method

Direct

1. Continuous Internal Assessment (CIA)-T1 & T2
2. Assignments, Seminars and Quizzes
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Indirect

1. Student Participation in co-curricular activities
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