PERIYAR UNIVERSITY

Periyar Palkalai Nagar, Salem-636011

(Reaccredited with 'A' Grade by the NAAC)

DEPARTMENT OF ENVIRONMENTAL SCIENCE

M.Sc. ENVIRONMENTAL SCIENCE

[Choice Based Credit System (CBCS)]

OBE SYLLABUS

(Effective from the academic year 2019-2020 and thereafter)

M. Sc. ENVIRONMENTAL SCIENCE

OBE REGULATIONS AND SYLLABUS

(With effect from the academic year 2019-2020 onwards)

1. Preamble

Growing populations and high standards of living put increasing pressure on our environment. Since the beginning of industrialization and urbanization, we have been facing with an increasing number of environmental challenges such as air, water and soil contamination, energy crisis, land degradation, deforestation, loss of biodiversity, global warming and climate change, etc., Considering the above issues, addressing environmental problems from a scientific perspective is utmost important for today's world. So, there is a need to develop the next generation as skilled professionals in a multidisciplinary Environmental Science programme to solve the environmental issues.

2. General Graduate Attributes

1. ***Environmental Knowledge***

   Apply the basic knowledge of environmental components and its interactions and to conceptualize the domains towards environmental protection and to visualize the environmental management perspectives

2. ***Critical Thinking Skills***

   To analyze and evaluate critically, the issues related to the environment, and biosphere and pollution related issues and delineating the possible factors for environmental sustainability

3. ***Research Skills***

   Improve the research-oriented skills by involving into the specific need-based research works and thereby enhancing the research-oriented work environment

4. ***Problem Solving Skills***

   Identify, analyze and assess the complex environmental issues and to apply the knowledge to solve the issues

5. ***Environment Management***

   To improve oneself to undertake and manage environment related works and to develop a leadership quality and capacity to manage a team for carrying out assigned or specific tasks.

6. ***Technical Skills***

   To acquire and equip oneself with technical knowledge on critical environmental problems and to devise technical strategies for the betterment of the environment.

7. ***Use of Modern Tools***

   To acquire the knowledge and working experience on modern tools in terms of instrumentation, softwares and research methods which can be used to assess the environmental quality.

8. ***Project Management***

To manage and coordinate specific environmental work, tasks or projects and to apply specific principles and methodologies to carry out environmental project works.

9. ***Societal and Environmental Concern***

To have appealing concern over the environment and its well being, and to apply the acquired knowledge and skills for the societal upliftment and for sustainable environment.

10. ***Individual and Team Work***

To develop the skill of working individually and to be a part of a team as an effective team member or a leader of the team in order to manage projects related to environment

11. ***Innovation and Entrepreneurship***

To develop skills of innovation and entrepreneurship in the field of environmental technology to initiate small scale start-ups and upscale the process towards entrepreneurship**.**

3. Programme Specific Qualification Attributes

- **Knowledge and understanding level (K1 and K2)**

Students can understand the fundamentals of ecology, environment, biodiversity and natural resources their process for sustainable development. The students can understand the basics of pollutant and their toxic effects.

- **Application level (K3)**

Students will be capable of applying microbes for potential environmental cleanup and green energy production, and to generate value-added products through waste recycling.

Analytical level (K4)

Students can analyze the environmental parameters of each and every aspects of and biochemical reaction in animals including human being.

- **Evaluation capability level (K5)**

Students can acquire the capability of evaluating the responsible factors for any kind of environmental related issues and can be able to apply the acquired knowledge in providing solutions to the environmental problems

- **Scientific or synthesis level (K6)**

Students will be able to synthesize or develop new processes or products or to formulate new scientific tools related to environment

4. Vision

- Creating and Maintaining Excellence in Environmental Science and contributing our knowledge and effort in bringing up rich posterity.

5. Programme Objectives and Outcomes

Programme Educational Objectives (PEOs)

Post graduates of M.Sc. Environmental Science program will be

PEO1	Utilizing domain knowledge to understand the environment and to provide solutions for the development of society.
PEO2	Applying research and acquired skills with a rich set of communication and leadership skills to sustain in the environment.
PEO3	Expressing constant development in their specialized career through life-long learning, appreciating human values and ethics.

Programme Outcomes (PO)

After successful completion of the two years M.Sc. Environmental Science Programme, the students are expected to have

PO1	Deep knowledge in natural resources, ecosystem and their biogeochemical processes, biodiversity, GIS and their importance, various elements of climate change and environmental clearance procedures.
PO2	Good understating in toxicological properties of environmental pollutants and their impact on environment, occupational diseases, nanomaterials and their toxicity.
PO3	Capability in applying microbes for potential environmental cleanup and energy production, and to generate value added products through waste recycling and other sustainable environmental management practices.
PO4	Acquire more knowledge and proficiency in Environmental Impact Assessment, auditing, pollution monitoring and management.
PO5	Skills in methods used for EIA studies, remote sensing and Geographic Information Systems to monitor the environmental issues and critically analyzing the global climate change issues.
PO6	Expertise to become as environmental consultants / managers at local, regional and national levels industries / institutions /organizations.
PO7	Capability to become an entrepreneur in the field of EIA, waste management and waste recycling, natural product, environmental safety trainer.
PO8	Qualification to be employed as a researcher / scientist / faculty in colleges / universities / Research organizations.

Candidate's eligibility for admission

Candidates who have passed the B.Sc. degree in Environmental Science / Life Sciences / Botany / Zoology / Microbiology / Biotechnology / Biochemistry / Chemistry / Physics / Bioinformatics / Home Science / Food Science & Nutrition of this University or an Examination of any other University accepted by the Syndicate as equivalent thereto shall be eligible for admission to M.Sc. Degree Course in Environmental Sciences.

6. Duration of the programme

The duration of the M.Sc. Environmental Science shall be over a period of **Two Years** from the commencement of the course.

7. CBCS- Structure of the Programme

The programme structure comprises of two parts.

Course Component	No. of Courses	Hours of Learning	Marks	Credits
Part A (Credit Courses)				
Core Courses	13	845 (65 hrs per course)	1300	59
Elective Courses	2	104 (52 hrs per course)	200	8
Supportive Courses	2	78 (39 hrs per course)	200	6
Lab Course	3	234 (78 hrs per course)	300	9
Research Project	1	468 (26 hrs per week)	150	6
Field visit	1	-	50	2
Online Courses (SWAYAM)	2	-	200	4
Total	**24**	**1729**	**2400**	94
Part B (Self-Learning Credit Courses)				
Industry oriented course	2	36 (36 hrs per course)	100	2
Total	26	1765	2500	96

8. Curriculum structure for each semester as per courses alignment

Main syllabus (Attached as Annexure I)

9. Credit Calculation

Method of teaching	Hours	Credits
Lecture	1	1
Tutorial/Demonstration	1	1
Practical/Internship/Self-Learning	2	1

CBCS – Scheme of Examinations semester wise structure

S. No.	Paper type	Paper Code	Title of the Paper	Weekly Contact Hours	Credits	Internal Marks	External Marks	Total Marks
			SEMESTER - I					
1	Core - I	19UPEVS1C01	Ecology and Biodiversity Conservation	5	5	25	75	100
2	Core - II	19UPEVS1C02	Environmental Chemistry	5	5	25	75	100
3	Core - III	19UPEVS1C03	Environmental Microbiology	5	4	25	75	100
4	Core - IV	19UPEVS1C04	Environmental Biochemistry and Toxicology	5	4	25	75	100
5	Elective - I	19UPEVS1E01/ 02/03/04/05	Elective Paper	4	4	25	75	100
6	Practical - I	19UPEVS1P01	Practical Paper I	6	3	40	60	100
			Sub Total	30	25	165	435	600
			SEMESTER - II					
7	Core - V	19UPEVS2C05	Environmental Pollution and Control Strategies	5	5	25	75	100
8	Core - VI	19UPEVS2C06	Environmental Geoinformatics	6	5	25	75	100
9	Core - VII	19UPEVS2C07	Climate Change and Current Issues	5	4	25	75	100
10	Elective - II	19UPEVS1E01/ 02/03/04/05	Elective Paper	4	4	25	75	100
11	Supportive - I	19UPEVS1S01/ 02/03/04	Supportive - I	3	3	25	75	100
12	Practical - II	19UPEVS2P02	Practical Paper - II	6	3	40	60	100
	External Credit	19UPEVS2EC1	Industrial - Institution - Collaboration	1	1	20	30	50
			Sub Total	30	24			
			SEMESTER - III					
13	Core - VIII	19UPEVS3C08	Waste Management	5	5	25	75	100
14	Core - IX	19UPEVS3C09	Environmental Impact Assessment	5	5	25	75	100
15	Core - X	19UPEVS3C10	Environmental Biotechnology	5	5	25	75	100
16	Core - XI	19UPEVS3C11	Research Methodology and Instrumentation	5	4	25	75	100
17	Supportive II	19UPEVS1S01/ 02/03/04	Supportive - II	3	3	25	75	100

18	Practical - III	19UPEVS3P03	Practical Paper - III	6	3	40	60	100
	External Credit	19UPEVS2EC2	Industrial - Institution - Collaboration	1	1	20	30	100
				30	25			
			SEMESTER - IV					
19	Core - XII	19UPEVS4C12	Environmental Law and Policies	5	4	25	75	100
20	Core - XIII	19UPEVS4C13	Environmental Health and Safety	5	4	25	75	100
21	Core I.V.	19UPEVS4CIV	Industrial Visits / Study Tour	-	2	-	50	50
22	Project	19UPEVS4CPR	Research Project	20	6	50	100	150
			Sub Total	30	16			
			Total	120	90			

Elective Courses

S.No	Course Code	Title of the Paper	Weekly Contact Hours	Credits	Internal Marks	External Marks	Total Marks
1	19UPEVS1E01	Energy Resources and Environmental Sustainability	4	4	25	75	100
2	19UPEVS1E02	Eco-Tourism and Wild Life Management	4	4	25	75	100
3	19UPEVS1E03	Environmental Nanotechnology	4	4	25	75	100
4	19UPEVS1E04	Environmental Engineering	4	4	25	75	100
5	19UPEVS1E05	Environmental Economics	4	4	25	75	100

Supportive Courses (Non-Major Course)

S.No	Course Code	Title of the Paper	Weekly Contact Hours	Credits	Internal Marks	External Marks	Total Marks
1	19UPEVS1S01	Ecology and Environment	3	3	25	75	100
2	19UPEVS1S02	Environmental Pollution	3	3	25	75	100
3	19UPEVS1S03	Environmental Health and Safety	3	3	25	75	100
4	19UPEVS1S04	Global Environmental Issues and Management	3	3	25	75	100

10. Examinations

Examinations are conducted in semester pattern. The examination for the Semester I & III will be held in November/December and that for the Semester II and IV will be in the month of April/May. Candidates failing in any subject (both theory, practical and skill) will be permitted to appear for such failed subjects in the same syllabus structure at subsequent examinations within next 5 years. Failing which, the candidate has to complete the course in the present existing syllabus structure.

11. Scheme for Evaluation and Attainment Rubrics

Evaluation will be done on a continuous basis and will be evaluated four times during the course work. The first evaluation will be in the 7th week, the second in the 11th week, third in the 16th week and the end – semester examination in the 19th week. Evaluation may be by objective type questions, short answers, essays or a combination of these, but the end semester examination is a University theory examination with prescribed question paper pattern.

Attainment Rubrics for Theory Courses

Internal *(Max. Marks - 25)*

Attendance	Seminar	Assignment	Cycle Test	Total
5	5	5	10	25

External (Max. Marks - 75)

Question Paper Pattern (Theory)

Section	Approaches	Mark Pattern	K Level
A	One Word (Answer all questions)	20 x 1 = 20 (Multiple Choice Questions)	K1, K2
B	100 to 200 words (Answer any three out of five questions)	3 x 5 = 15 (Analytical type questions)	K3, K4
C	500 to 1000 words	5 x 8 = 40 (Essay type questions)	K5, K6

Attainment Rubrics for Lab Courses

Internal (Max. Marks - 40)

Attendance	Practical Test	Periodical Performance/Observation	Total Marks
5	25	10	40

External (Max. Marks - 60)

Major Experiment	Minor Experiment	Spotters	Record	Viva-Voce	Total Marks
20	15	15	5	5	60

Attainment Rubrics for Research

Internal (Max. Marks - 50)

Periodical Review and Results Presentation	50 Marks

External (Max. Marks - 100)

Vivo-Voce Presentation	25 Marks
Dissertation	75 Marks

Passing Minimum

- There shall be no Passing Minimum for Internal.
- For External Examination, Passing Minimum shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
- In the aggregate (External + Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-Voce.
- Grading shall be based on overall marks obtained (internal + external).

12. Grading System

Evaluation of performance of students is based on ten-point scale grading system as given below.

Ten Point Scale			
Grade of Marks	**Grade points**	**Letter Grade**	**Description**
90-100	9.0-10.0	O	Outstanding
80-89	8.0-8.9	D+	Excellent
75-79	7.5-7.9	D	Distinction
70-74	7.0-7.4	A+	Very Good
60-69	6.0-6.9	A	Good
50-59	5.0-5.9	B	Average
00-49	0.0	U	Re-appear
ABSENT	0.0	AAA	ABSENT

Semester I

CORE COURSE - I

ECOLOGY AND BIODIVERSITY CONSERVATION

Paper Code	19UPEVS1C01	Horus	L	T	P	Credit
Marks	100		4	1	-	5

Course Objectives

The purpose of this course is to gain an understanding of the value of biodiversity and drivers of its loss; current efforts to conserve biodiversity on global, national and local scales; practical issues with local conservation and organizations, policies and programmes for sustainable management of bioresources.

Course Outcomes

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

CO1 Understand the relationship between biodiversity and ecosystem functions

CO2 Understand the direct and indirect values of biodiversity resources and their bioprospecting opportunities

CO3 Assess the factors responsible for the loss of biodiversity

CO4 Outline the main reasons for decline and threats to biodiversity worldwide

CO5 Evaluate the pros and cons of species introductions and reintroductions

CO6 Understand the various *in situ* and *ex situ* conservation measures and make critical judgments on the conflict between conservation and development

CO7 Argue the case for local action to address the global loss of biodiversity

CO8 Know more knowledge about the recent policies and programmes for sustainable management of bioresources and apply the rules and recommendations related to environmental protection

Mapping with Programme Outcomes

The mapping of course outcomes with programme outcomes is tabulated as follows:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3	*							
CO4	*							*
CO5	*					*		*
CO6	*					*		*
CO7	*					*		*
CO8	*					*		*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Ecology and Biodiversity	Ecology: Types of ecosystem – Terrestrial and Aquatic ecosystems - Ecological pyramids - Food Chain - Food Web - Energy flow (K1 & K2) - Types of Biodiversity: Species, Genetic and Ecosystem diversity – Alpha, beta, and gamma diversity (K1 & K2) – Biodiversity and ecosystem function (K4 & K5) – Megadiversity zones and Biodiversity Hot Spots in India (K2 & K3) – Ecologically Sensitive Areas (ESA) in India (K4 & K5) - Values of Biodiversity (K4 & K5) – Biodiversity Prospecting - Examples of biopiracy and bioprospecting (K2 & K5)	8
II	Threats to Biodiversity	Endangered and endemic species of flora and fauna in India (K1 & K2) - Biodiversity threats under Anthropocene era: Habitat loss, fragmentation and degradation – Pollution - Overexploitation (K2, K4 & K5) - Human-Animal conflict with special reference to elephants (K2, K4 & K5) – IUCN Threat Categories – Red Data Book (K2 & K4) – Climate change on species extinction - Causes and Impacts of Invasive species to biodiversity (K2, K3, K4 & K5) – Global Taxonomy Initiative to combat invasive alien species (K1 & K2)	8
III	Conservation Strategies	*In situ* conservation: Afforestation, Social Forestry, Agro-forestry, Zoos, Biosphere Reserves, National Parks, Sanctuaries, Protected Area Network, Sacred Groves and Sthalavrikshas (K1, K2 & K3) – *Ex situ* conservation: Botanical gardens, Cryopreservation, Gene Bank, Seed Bank, Pollen Bank, Sperm Bank, cDNA Bank (K1, K2 & K3) - Conservation Genomics: Environmental DNA (eDNA) for wildlife biology and biodiversity monitoring, Next Generation Sequencing (NGS) Techniques, DNA barcodes, Transcriptome and Epigenome tools, CRISPR based gene drives (K2, K4, K5 & K6)	12
IV	Sustainable Management of Bioresources	An elementary account on WTO, GAAT and TRIPS to agricultural biodiversity (K2 & K4) - National Biodiversity Authority (NBA) – Functions of State Biodiversity Board (SBB) and Biodiversity Management Committee's (BMC) – People's Biodiversity Register (PBR) (K1, K2 & K4) – Biodiversity informatics Portals (K4 & K5) - International Organizations and biodiversity conservation: Objectives and Targets 2011-2020 of Global Strategy for Plant Conservation (GSPC), WWF-India for priority and threatened species conservation, UNESCO - Man and Biosphere Programme (MAB), UNDP - Biodiversity Finance Initiative (BIOFIN) and UNEP – Global Environment Facility (GEF) for biodiversity conservation (K3, K4 & K5)	12

V	Policies, Programmes and Acts for Conservation	Salient features of Biological Diversity Act 2002 (K2 & K3) - Status and protection of species in National and International levels – Policies implemented by MoEF & CC for biodiversity conservation - Role of CITES, IUCN and Convention on Biological Diversity (CBD) in biodiversity conservation (K2, K3 & K4) – Nagoya Protocol on Access and Benefit-Sharing – Cartagena Protocol on Biosafety - The Aichi Biodiversity Targets (K3) – Monitoring the Illegal Killing of Elephants (MIKE) programme – Strategic programme 2016-2020 for The International Consortium on Combating Wildlife Crime (ICCWC) – SAWEN and TRAFFIC Networks to combat illegal wildlife trade – Ramsar Strategic Plan 2016-2024 for wetland conservation (K4 & K5)	10

References

Text Books

1. Eugene P. Odum and Gary W. Barrett. (2004) Fundamentals of Ecology (5th Edition) Brooks/Cole Publishers.
2. Krishnamurthy KV (2003) An Advanced Textbook on Biodiversity – Principles and Practice, Oxford and IBH Publishing, New Delhi.

Reference Books

1. Alonso A. Aguirre and Raman Sukumar (2017) Tropical Conservation. Perspectives on Local and Global Priorities, Oxford University Press, USA.
2. Chaudhuri AB and Sarkar DD (2003) Megadiversity Conservation, Flora, Fauna and Medicinal Plants of India's Hot Spots. Daya Publishing House, New Delhi.
3. Dadhich LK and Sharma AP (2002) Biodiversity –Strategies for Conservation, APH Publishing Corporation, New Delhi.
4. John Kress W, Carlos García-Robledo, Maria Uriarte and David L. Erickson (2015) DNA barcodes for ecology, evolution, and conservation. Trends in Ecology and Evolution. 30:25-35.
5. John-James Wilson, Kong-Wah Sing, Ping-Shin Lee and Alison K. S. Wee (2016) Application of DNA barcodes in wildlife conservation in Tropical East Asia. Conservation Biology. 30:982-989.
6. Kristine Bohmann, Alice Evans, M. Thomas P. Gilbert, Gary R. Carvalho, Simon Creer, Michael Knapp, Douglas W. Yu and Mark de Bruyn (2014) Environmental DNA for wildlife biology and biodiversity monitoring. Trends in Ecology and Evolution. 29:358-367.
7. Muthuchelian K (2013) Glimpses of Animal Biodiversity, Astral International (P) Ltd., New Delhi.
8. Muthuchelian K (2013) Uyir Virimam (Tamil), Pranisha Pathippagam, Madurai.
9. Muthuchelian K (2016) Bioinformatics, Barcoding and Benefit Sharing in Biodiversity Educationist Press, New Delhi.
10. Richard Frankham, Jonathan D Ballou and David A. Briscoe (2010) Introduction to Conservation Genetics, Second edition, Cambridge University Press, UK.
11. William V. Holt, Janine L. Brown and Pierre Comizzoli (2014) Reproductive Sciences in Animal Conservation. Progress and Prospects, Springer, New York.

Web Resources

1. www.iucn.org
2. www.cites.org
3. www.cbd.int
4. www.wri.org
5. http://www.traffic.org
6. http://www.sawen.org
7. https://cites.org/sites/default/files/eng/prog/iccwc/ICCWC_Strategic_Programme_2016-2020_final.pdf
8. http://www.ramsar.org/sites/default/files/hb2_5ed_strategic_plan_ 2016_24_e.pdf
9. https://www.thegef.org/topics/biodiversity
10. https://www.cbd.int/gspc/strategy.shtml

CORE COURSE – II

ENVIRONMENTAL CHEMISTRY

Paper Code	19UPEVS1C02	Horus	L	T	P	Credit
Marks	100		4	1	-	5

Course Objectives

The purpose of this course is to develop an understanding of environment, chemicals and their effects on the environment, to provide students with an understanding of the fundamental chemical processes and pollutants effects on environment.

Course Outcomes

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

CO1	Have knowledge of basic theories and problems of Environmental chemistry
CO2	Describe important chemical reactions and cyclic processes of chemical species in the atmosphere, hydrosphere and in lithosphere
CO3	Demonstrate knowledge of chemical principles of various fundamental environmental Phenomena
CO4	Apply basic chemical concepts in understanding the behavior of pollutants
CO5	To analyze chemical processes involved in air, water and soil environmental problems
CO6	Know the different types of toxic and hazardous substances and analyze their toxicological information

Mapping with Programme Outcomes

The mapping of course outcomes with programme outcomes is tabulated as follows:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							*
CO2		*				*		
CO3		*				*		*
CO4		*						
CO5		*	*	*		*		*
CO6						*		*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Fundamentals of Environmental Chemistry	Definition - Concept and Scope (K1 & K2)- Preparation of Standard Solutions – Molarity, Molality, Normality, Percent and PPM (mg/l) Solutions (K3 & K4)- Stoichiometry - Gibb's energy - Chemical Potential - Chemical Equilibria - *Acid-base Reactions*: pH and pOH and Buffer Solutions - Solubility and Solubility Product - Solubility of Gases in Water - The Carbonate System - Unsaturated and Saturated Hydrocarbons – Radionuclides (K3 & K4)	10
II	Atmospheric Chemistry	Classification of Elements (K2 & K3) – Particles, Ions and Radicals (K2) - Formation of Inorganic and Organic Particulate Matter - Thermochemical and Photochemical Reactions in the Atmosphere - Oxygen and Ozone Chemistry - Chemistry of Air Pollutants (Oxides of Carbon, Nitrogen, Sulphur) (K4 & K5).	12
III	Water Chemistry	Formation of Water (K1) - Water Resources – Sources and Types (K1) - Hydrological Cycle - Unique Properties of Water (K2) - Role of Water in the Environment (K3)- Physical, Chemical and Biological Parameters of Water – Phenomenon of Eutrophication - Concept of DO, BOD, COD - Distribution of Chemical Species in Water - Organic Matter and Humic Matter in Water (K4 & K5)	12
IV	Soil Chemistry	Nature of soil – Formation and Types (K1 & K2)- *Mechanical, Physical and Chemical Properties of Soil*: Soil Structure, Texture, Temperature, Bulk Density, Permeability, Moisture, Air, pH, Cation Exchange Capacity, Macro and Micronutrients, Humus and Organic Matter, C/N Ratio (K3, K4 & K5)	12
V	Pollutant Chemistry	Chemistry of various Organic and Inorganic Compounds - Chemistry of Hydrocarbon Decay (K3)- Effects on Macro and Microorganisms (K4) – Surfactants - Cationic, anionic and non-ionic detergents, modified detergents (K1 & K5) - *Pesticides*: Classification, Degradation, Analysis - Pollution due to Pesticides – DDT and Endosulphan - *Heavy metals*- Toxic effects of Ar, Cd, Pb & Hg (K3, K4 & K5)	12

References

Text Books

1. De, A.K. (2007) Environmental Chemistry, Seventh Edition, New Age International Publishers.
2. Sharma, B.K and H. Kaur, (1994) Environmental Chemistry, Goel Publishing House Ltd., Meerut, UP.

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1. Balram Pani, (2007) Text Book of Environmental Chemistry, I.K. International Publishing House PVT. Ltd.
2. Manahan, S.E. (2010), Environmental Chemistry, Ninth Edition, CRC Press
   Dara, S.S and D.D. Mishra (2009) A Text Book of Environmental Chemistry and Pollution Control, 10th edition, S. Chand & Company

Journals and Documents

1. http://www.nptel.ac.in/courses/122106030/Pdfs/3_1.pdf
2. http://www.crystal.med.upenn.edu/sharp-lab-pdfs/sharp_EncLifeSci.pdf
3. http://www.fao.org/docrep/field/003/AC172E/AC172E04.htm
4. http://www.essentialchemicalindustry.org/materials-and-applications/surfactants.html
5. http://agriinfo.in/?page=topic&superid=5&topicid=174
6. http://www.citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.800.8713&rep=rep1...pdf

CORE COURSE – III

ENVIRONMENTAL MICROBIOLOGY

Paper Code	19UPEVS1C03	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives:

1. To learn the basic knowledge about Microbiology

2. To know the role of microbes and microbial interactions in soil and other soil activities in Environmental field

3. To understand the biogeochemical cycles prevail in Environment

4. To enhance the skill on microbial analysis of Environment.

Course Outcomes

CO1	Able to understand about microbes in environmental field
CO2	Understand the role of microbes in soil fertility, biogeochemical cycles, plant growth promotion
CO3	Know about the impact of microbial air and water pollutants
CO4	Understand the microbial diseases related to environment
CO5	Apply the microbial processes to clean the environment.
CO6	To enhance the skill on microbial analysis of environment

Mapping course outcomes with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2		*						
CO3			*					
CO4			*					
CO5					*			
CO6				*				

ENVIRONMENTAL MICROBIOLOGY

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Introduction to Microbiology**	History and scope of microbiology – General structure and functions of Bacteria, Fungi, Virus and algae – Physical and Chemical methods of Sterilization techniques used in microbiology - Preparation of media for isolation and culture of microorganisms. **(K1, K2)**	7
II	**Geomicrobiology**	Soil micoflora – Factors influencing the soil microflora – Role of microorganisms in soil fertility. Microbial interactions – Mutualism, Commensalism, Competition, Amensalism, Parasitism and Predation. Interaction between microbes and plants: Rhizosphere, phyllosphere and mycorrhizae. **(K1, K2)**	7
III	**Biogeochemical Cycles**	Carbon cycle - Role of microbes in Carbon cycle - Nitrogen cycle - Mechanism of biological nitrogen fixation - Ammonification, Nitrification, Denitrification - Phosphorous cycle and Sulphur cycle - Phosphate solubilization. **(K3, K4, K5)**	10
IV	**Air and Water-Borne Diseases**	Microbial air pollutants - Bioaerosols, Aero allergens – Airborne diseases, Symptoms and preventive measures - Water pollution: Sources and nature of pollutants in water – waterborne diseases, Symptoms and preventive measures (Cholera and Typhoid). Microbial assessment of water quality - MPN technique and Biological Oxygen Demand. **(K5, K6)**	10
V	**Applied Microbiology**	Microbial conversion of solid waste to food (Mushroom, SCP), fuels (Biogas, Ethanol), Bioleaching of Ores, Biodegradation of Lignin – Bioremediation: Types and its application – Bio deterioration of paper, wood - Metal Corrosion. **(K4, K5)**	10

References

Text Books

1. Dubey and Maheshwari, 1999, A text book of Microbiology, 1/e, Chand publications, New Delhi.
2. Mohapatra P K (2008)Text Book of Environmental Microbiology, I K International Publishing House Limited

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2. SubbaRao NS (1995) Biofertilizers in Agriculture and Forestry.3rd Edition, Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi.
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CORE COURSE – IV

ENVIRONMENTAL BIOCHEMISTRY AND TOXICOLOGY

Paper Code	19UPEVS1C04	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives:

The purpose of this course is to focus on understanding the role of pollutants, xenobiotics in the natural environment and to understand the basics of environmental toxicology, cell biology and biochemistry and to characterize the adverse effects of chemical substances on the ecosystem and humans.

Course Outcomes

CO1 Acquire broad knowledge of the field of environmental toxicology and biochemistry

CO2 Understand the basic principles, target organ toxicity and the toxicity of a select group of chemical compounds.

CO3 Synthesize and apply concepts from multiple sub-disciplines in environmental cell biology, biochemistry and toxicology.

CO4 Use technical and analytical skills to quantify the level xenobiotics in environmental compartments.

CO5 Understand the effects of xenobiotics in on human health.

CO6 Understand relationships between chemical/drug exposure and their effects on physiological systems.

CO7 Acquire skill is toxiciolgical bioassays.

CO8 Design strategies for study of dose-response relationships

Mapping of course outcomes with programme outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2		*						
CO3			*					
CO4			*					
CO5					*			
CO6				*				
CO7						*		
CO8								*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Basic Cell Biology**	Prokaryotic and Eukaryotic cell structure and intracellular organelles – Cell wall, membranes, nucleolus, endosomes, peroxisomes, mitochondria,	10

		endoplasmic reticulum, plant vacuoles, plastids, microbodies and chloroplast. Cell growth and division- Meiosis and Mitosis, genotypes and phenotypes **(K1, K2)**	
II	**Cellular Processes**	Cellular permeability, diffusion, osmosis, absorption of water, transpiration, photosynthesis, Respiration, translocation of solutes, Photoperiodism and vernalisation, plant movements, Dormancy, senescence. Animal Phylogeny. **(K1, K2)**	10
III	**Basics of Toxicology**	Introduction to toxicology, scope and types - Classification of toxic agents. Routes of exposure, duration and frequency of exposure, Dose response relationship - LC_{50} LD_{50}, Margin of safety levels. Environmental Risk – Definition, Risk Characterization - Hazard Identification, Exposure Assessment Methods, Risk Assessment – National and International guidelines. Environmental Risk – Mitigation measures.**(K3, K4, K5)**	10
IV	**Toxicity Testing and Bioassay**	Toxicity testing –laboratory animals, toxicity testing in animals, toxicological field studies, Concepts of Bioassay, Types and characteristics - Field based microbial bioassay, Test models and classification - Immunotoxicity, histotoxicity and cell toxicity. **(K5, K6)**	7
V	**Xenobiotics**	Toxicity testing –laboratory animals, toxicity testing in animals, toxicological field studies, Concepts of Bioassay, Types and characteristics - Field based microbial bioassay, Test models and classification - Immunotoxicity, histotoxicity and cell toxicity. **(K4, K5)**	7

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Text Books

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2. Alberts B, Johmson A, Lewis J, Raff M, Roberts K and Walter P (2002) Molecular Biology of the Cell, Garland Science, New York.

Reference Books

1. Buchanan BB, Gruissem W and Jones RL (2002) Biochemistry and Molecular Biology of Plants, ASPB, USA.
2. Cooper GM and Hausman RE (2013) The Cell: A Molecular Approach, 6th edition, Sinauer Associates, Sunderland, MA, USA.
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SEMESTER - II

CORE – V

ENVIRONMENTAL POLLUTION AND CONTROL STRATEGIES

Paper Code	19UPEVS2C05	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives

The purpose of this course is to gain awareness of environmental pollution and an overview of causes and consequences to natural, economic and social systems, to understand the fundamental principles governing the interactions between transport of pollutants in the environment

Course Outcomes

CO1	Learn about the air, water and soil pollutants, sources and its effects
CO2	Have clear understanding on the air, water, noise and radiation standards and its techniques
CO3	Apply relevant techniques, skills and modern engineering tools to solve the environmental problems
CO4	Get exposed good practice of technologies and options used to remediate reduce/eliminate pollution of the environment
CO5	Understand problems in order to select control measures and techniques concerning atmospheric, water or terrestrial challenges
CO6	Understand the ill effects of pollution and Create awareness to public on Environmental pollution and its control

Mapping of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							*
CO2		*				*		
CO3		*				*		*
CO4		*						
CO5		*	*	*		*		*
CO6						*		*

ENVIRONMENTAL POLLUTION AND CONTROL STRATEGIES

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Fundamentals of Environmental Chemistry	Definition - Concept and Scope (K1 & K2)- Preparation of Standard Solutions – Molarity, Molality, Normality, Percent and PPM (mg/l) Solutions (K3 & K4)- Stoichiometry - Gibb's energy - Chemical Potential - Chemical Equilibria - *Acid-base Reactions*: pH and pOH and Buffer Solutions - Solubility and Solubility Product - Solubility of Gases in Water - The Carbonate System - Unsaturated and Saturated Hydrocarbons – Radionuclides (K3 & K4)	10
II	Atmospheric Chemistry	Classification of Elements (K2 & K3) – Particles, Ions and Radicals (K2) - Formation of Inorganic and Organic Particulate Matter - Thermochemical and Photochemical Reactions in the Atmosphere - Oxygen and Ozone Chemistry - Chemistry of Air Pollutants (Oxides of Carbon, Nitrogen, Sulphur) (K4 & K5).	12
III	Water Chemistry	Formation of Water (K1) - Water Resources – Sources and Types (K1) - Hydrological Cycle - Unique Properties of Water (K2) - Role of Water in the Environment (K3)- Physical, Chemical and Biological Parameters of Water – Phenomenon of Eutrophication - Concept of DO, BOD, COD - Distribution of Chemical Species in Water - Organic Matter and Humic Matter in Water (K4 & K5)	12
IV	Soil Chemistry	Nature of soil – Formation and Types (K1 & K2)- *Mechanical, Physical and Chemical Properties of Soil*: Soil Structure, Texture, Temperature, Bulk Density, Permeability, Moisture, Air, pH, Cation Exchange Capacity, Macro and Micronutrients, Humus and Organic Matter, C/N Ratio (K3, K4 & K5)	12
V	Pollutant Chemistry	Chemistry of various Organic and Inorganic Compounds - Chemistry of Hydrocarbon Decay (K3)- Effects on Macro and Microorganisms (K4) – Surfactants - Cationic, anionic and non-ionic detergents, modified detergents (K1 & K5) - *Pesticides*: Classification, Degradation, Analysis - Pollution due to Pesticides – DDT and Endosulphan - *Heavy metals*- Toxic effects of Ar, Cd, Pb & Hg (K3, K4 & K5)	12

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Text Books

1. De, A.K. (2007) Environmental Chemistry, Seventh Edition, New Age International Publishers.
2. Sharma, B.K and H.Kaur, (1994) Environmental Chemistry, Goel Publishing House Ltd., Meerut, UP.

Reference Books

1. Balram Pani, (2007) Text Book of Environmental Chemistry, I.K. International Publishing House PVT. Ltd.
2. Manahan, S.E. (2010), Environmental Chemistry, Ninth Edition, CRC Press
   Dara, S.S and D.D. Mishra (2009) A Text Book of Environmental Chemistry and Pollution Control, 10th edition, S. Chand & Company.

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2. http://www.*crystal.med.upenn.edu/sharp-lab-pdfs/sharp_EncLifeSci.pdf*

3. http://www.fao.org/docrep/field/003/AC172E/AC172E04.htm

4. http://www.essentialchemicalindustry.org/materials-and-applications/surfactants.html

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CORE – VI

ENVIRONMENTAL GEOINFORMATICS

Paper Code	19UPEVS2C06	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives

The purpose of this course is to introduce the principles, processes and application of Remote sensing and GIS, and to impart practical knowledge on the use of remote sensing and GIS techniques for Environmental management.

Course Outcomes

CO1 Acquaint adequate knowledge on the use of remote sensing.
CO2 Know the basic concepts of GIS and its mechanisms
CO3 Know to interpret satellite images
CO4 Understand Image Classification Techniques, Image enhancement and interpretation Methods
CO5 Know the various types of GPS systems
CO6 Use GPS for various environmental applications
CO7 Able to apply the tools of remote sensing and GIS for environmental disaster management and conservation

Mapping of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*				*			
CO2					*			
CO3					*			
CO4						*		
CO5					*			
CO6				*				
CO7								*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Remote Sensing**	Environmental Geoinformatics – Introduction - Principles of Remote Sensing and GIS Electromagnetic Radiation, EMR Spectrum- Properties – Use in Environmental	7

		Geoinformatics Geoinformatics in India **(K1, K2)**	
II	**Image Interpretation and Analysis**	Principles of visual Interpretation of aerial photos and satellite imagery Recognition Elements and Interpretation keys for Visual Interpretation Techniques Image Enhancement Techniques-Linear Non- linear Contrast Enhancement Filtering - Principles of Image Classification Feature Selection Supervised Classification - Unsupervised Classification **(K2, K5, K6)**	10
III	**GIS concepts**	Introduction to Geographical Information Systems and GIS software, Fundamentals of GIS: Data structures - vector and raster data. Data input – storage - editing, Projection / Image registration, Digitization and data attributes -map data representation. **(K5, K6)**	10
IV	**GPS Concepts**	Introduction to GPS, Error Sources and Positioning, GPS Satellite Systems, Types of GPS, Elements of GPS types of GPS machines and its applications for surveying and mapping Global Navigation Satellite System.**(K1, K2, K3)**	10
V	**Application of Remote sensing and GIS**	Applications of remote sensing for land use/land cover, landscape mapping, vegetation analysis, climate change studies, flood, drought assessment desertification and water shed management. Application of GIS for environmental studies- decision support system, GPS-applications for surveying and mapping, interface of GPS data with GIS.**(K4, K5, K6)**	8

References

Text Books

1. Burrough, P. P. & McDonnel, R. A. (1998). Principles of GIS.Oxford University Press.
2. George Joseph, (2003).Fundamentals of Remote Sensing, Universities press (India) Pvt Ltd., Hyderabad.

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1. Chang, K. T. (2006). Introduction to Geographic Information Systems. The McGraw-Hill
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3. Jenson, J.R. (1996)..Introductory Digital Image Processing: Prentice Hall Series.

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5. http://www.istl.org/11-spring/internet.html

CORE – VII

CLIMATE CHANGE AND CURRENT ISSUES

Paper Code	19UPEVS2C07	Horus	L	T	P	Credit
Marks	100		4	1	-	5

Course Objectives

The purpose of this course is to focus on improving understanding of the climate system and climate science and the impacts of climate change, mitigation and/or adaptation to climate change and related issues.

Course Outcomes

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

CO1 Understand the climate and climate change processes at local to global scales
CO2 Empower the students to think critically about climate science
CO3 Sources and impacts of climate change due to anthropogenic activities especially energy utilization
CO4 Understand the existing novel technologies used for measurement of climate change and weather forecasting
CO5 Understand the recent initiatives and policy framework by UNFCCC, IPCC, CoP, MoEF&CC and other Ministries
CO6 Evaluate the successes and failures of past National and International efforts to address climate change mitigation and adaptation
CO7 Know how decisions about carbon emissions and other human activities might impact future climate during Anthropocene era
CO8 Evaluate prospects for future management of climate change

Mapping of course outcomes with programme outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3	*							
CO4	*							*
CO5	*					*		*
CO6	*					*		*
CO7	*					*		*
CO8	*					*		*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Ecology and Biodiversity	Ecology: Types of ecosystem – Terrestrial and Aquatic ecosystems - Ecological pyramids - Food Chain - Food Web - Energy flow (K1 & K2) - Types of Biodiversity: Species, Genetic and Ecosystem diversity – Alpha, beta, and gamma diversity (K1 & K2) – Biodiversity and ecosystem function (K4 & K5) – Megadiversity zones and Biodiversity Hot Spots in India (K2 & K3) – Ecologically Sensitive Areas (ESA) in India (K4 & K5) - Values of Biodiversity (K4 & K5) – Biodiversity Prospecting - Examples of biopiracy and bioprospecting (K2 & K5)	8
II	Threats to Biodiversity	Endangered and endemic species of flora and fauna in India (K1 & K2) - Biodiversity threats under Anthropocene era: Habitat loss, fragmentation and degradation – Pollution - Overexploitation (K2, K4 & K5) - Human-Animal conflict with special reference to elephants (K2, K4 & K5) – IUCN Threat Categories – Red Data Book (K2 & K4) – Climate change on species extinction - Causes and Impacts of Invasive species to biodiversity (K2, K3, K4 & K5) – Global Taxonomy Initiative to combat invasive alien species (K1 & K2)	8
III	Conservation Strategies	*In situ* conservation: Afforestation, Social Forestry, Agro-forestry, Zoos, Biosphere Reserves, National Parks, Sanctuaries, Protected Area Network, Sacred Groves and Sthalavrikshas (K1, K2 & K3) – *Ex situ* conservation: Botanical gardens, Cryopreservation, Gene Bank, Seed Bank, Pollen Bank, Sperm Bank, cDNA Bank (K1, K2 & K3) - Conservation Genomics: Environmental DNA (eDNA) for wildlife biology and biodiversity monitoring, Next Generation Sequencing (NGS) Techniques, DNA barcodes, Transcriptome and Epigenome tools, CRISPR based gene drives (K2, K4, K5 & K6)	12
IV	Sustainable Management of Bioresources	An elementary account on WTO, GAAT and TRIPS to agricultural biodiversity (K2 & K4) - National Biodiversity Authority (NBA) – Functions of State Biodiversity Board (SBB) and Biodiversity Management Committee's (BMC) – People's Biodiversity Register (PBR) (K1, K2 & K4) – Biodiversity informatics Portals (K4 & K5) - International Organizations and biodiversity conservation: Objectives and Targets 2011-2020 of Global Strategy for Plant Conservation (GSPC), WWF-India for priority and threatened species conservation, UNESCO - Man and Biosphere Programme (MAB), UNDP - Biodiversity	12

		Finance Initiative (BIOFIN) and UNEP – Global Environment Facility (GEF) for biodiversity conservation (K3, K4 & K5)	
V	Policies, Programmes and Acts for Conservation	Salient features of Biological Diversity Act 2002 (K2 & K3) - Status and protection of species in National and International levels – Policies implemented by MoEF & CC for biodiversity conservation - Role of CITES, IUCN and Convention on Biological Diversity (CBD) in biodiversity conservation (K2, K3 & K4) – Nagoya Protocol on Access and Benefit-Sharing – Cartagena Protocol on Biosafety - The Aichi Biodiversity Targets (K3) – Monitoring the Illegal Killing of Elephants (MIKE) programme – Strategic programme 2016-2020 for The International Consortium on Combating Wildlife Crime (ICCWC) – SAWEN and TRAFFIC Networks to combat illegal wildlife trade – Ramsar Strategic Plan 2016-2024 for wetland conservation (K4 & K5)	10

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Text Books

1. Eugene P. Odum and Gary W. Barrett. (2004) Fundamentals of Ecology (5th Edition) Brooks/Cole Publishers.
2. Krishnamurthy KV (2003) An Advanced Textbook on Biodiversity – Principles and Practice, Oxford and IBH Publishing, New Delhi.

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1. Alonso A. Aguirre and Raman Sukumar (2017) Tropical Conservation. Perspectives on Local and Global Priorities, Oxford University Press, USA.
2. Chaudhuri AB and Sarkar DD (2003) Megadiversity Conservation, Flora, Fauna and Medicinal Plants of India's Hot Spots. Daya Publishing House, New Delhi.
3. Dadhich LK and Sharma AP (2002) Biodiversity –Strategies for Conservation, APH Publishing Corporation, New Delhi.
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9. Muthuchelian K (2013) Uyir Virimam (Tamil), Pranisha Pathippagam, Madurai.

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11. William V. Holt, Janine L. Brown and Pierre Comizzoli (2014) Reproductive Sciences in Animal Conservation. Progress and Prospects, Springer, New York.

Web Resources

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5. http://www.traffic.org
6. http://www.sawen.org
7.https://cites.org/sites/default/files/eng/prog/iccwc/ICCWC_Strategic_Programme_2016-2020_final.pdf
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9. https://www.thegef.org/topics/biodiversity
10. https://www.cbd.int/gspc/strategy.shtml

SEMESTER - III

CORE - VIII

WASTE MANAGEMENT

Paper Code	19UPEVS3C08	**Horus**	**L**	**T**	**P**	**Credit**
Marks	**100**		**4**	**1**	**-**	**5**

Course Objectives

The purpose of this course is to understand the problems of different kinds of wastes and understand the proper collection, segregation and reduction methods for municipal waste, biomedical waste, hazardous waste, e-waste, industrial waste etc., To identify waste nature and proper disposal methods for each type of wastes and identify the energy producing wastes and recovery of the energy from the wastes using different techniques.

Course Outcomes

CO1 Understand health and environmental issues related to solid waste management; Select the appropriate method for solid waste collection, transportation, redistribution and disposal
CO2 Become aware of Environment and health impacts solid waste mismanagement
CO3 Understand engineering, financial and technical options for waste management and wealth from waste management techniques
CO4 Understand industrial specific wastes and their efficient management
CO5 Describe methods of disposal of hazardous solid waste
CO6 Understand the energy recovery and industrial specific treatment techniques

Mappings of course outcomes with programme outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1		*	*					
CO2		*					*	
CO3			*			*	*	
CO4		*				*	*	*
CO5				*		*	*	
CO6			*	*		*	*	*

WASTE MANAGEMENT

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Municipal Solid Waste Management**	Wastes – Introduction, Definition, Sources and Classification (K1 & K2); Municipal Solid Wastes – Source, Types, Per Capita Generation, Global Scenario Wastes (K3); Collection and Transportation Methods, Waste Processing and Material Recovery (TMRF), (K4) Effects of Municipal Solid Wastes on Environment. Disposal Methods (Landfill, Composting, Burning, Incineration, Pyrolysis, Anaerobic Digestion) (K5 & K6)	12
II	**Hazardous & Radioactive Waste Management**	Hazardous waste – Introduction (K1 & K2), Characteristics (K3), Classification of Hazardous Waste (Industrial, Hospital and Domestic) – Labeling and Handling of Hazardous Solid Wastes (Segregation, Recovery of Hazardous Waste Substances) (K3 & K4) - Hazardous Waste Disposal Techniques (K5). *Radioactive Wastes*: Sources, Types (K1 & K2), Effects (K3), Control and Disposal Methods (K4 & K5)	12
III	**Biomedical, Plastic & e-waste Management**	Biomedical Wastes: Sources, Types of Biomedical Wastes (K1 & K2), Impacts of Biomedical Wastes on Environment (K3 & K4) - Control Measures of Biomedical Wastes (K5). *Plastic Wastes*: Sources, Types 9K1 & K2), Facts & Figures of Plastic Waste Scenarios in National & International (K37 K4), Effects of Plastic Wastes on Environment, Control Measures of Plastic Wastes (K5 & K6). *E-wastes*: Sources, Types of e-wastes (K2) – Impacts of e-wastes on Environment (K3) - Control measures of e-wastes (K4)	12
IV	**Energy Recovery from Wastes**	Vermicomposting, mushroom cultivation, fly ash bricks, biogas, and electricity; Bioelectro chemical systems – Microbial electrolysis cell – Microbial fuel cell - Production of methane, ethanol, electricity (K3, K4 & K5).	10
V	**Industrial Waste Management**	Paper and Pulp, Tanneries, Textiles, Thermal Power Plants, Mining and Ore Processing, Refineries, Iron Casting, Cement and Asbestos. Waste Sludge Dewatering and its Disposal (K3- K6).	12

References

Text Books

1. Kinnaman, T.C and Takeuchi, K. (2014). Handbook on Waste Management, Edward Elgar Publishing, UK.
2. Ramesha Chandrappa and Jeff Brown, (2012). Solid Waste Management: Principles and Practice, Springer Science and Business Media Publishers.

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1. Basarkar Shishir, (2009) Hospital Waste Management: A Guide for Self-Assessment and Review, JAYPEEDIGITAL
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5. www.ipma.co.in/recycle.asp
6. linkinghub.elsevier.com/retrieve/pii/S026974910600042X
7. www.algae.info

CORE - IX

ENVIRONMENTAL IMPACT ASSESSMENT

Paper Code	19UPEVS3C09	Horus	L	T	P	Credit
Marks	100		4	1	-	5

Course Objectives

The purpose of this course is to introduce the methodology of environmental impact assessment (EIA) as a vital tool for sound environmental management and decision-making and to provide an overview of the concepts, methods, issues and various forms and stages of the EIA process.

Course Outcomes

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

CO1 Explain the major principles and components of EIA processes
CO2 List and comply with the environmental clearance procedures in India
CO3 Understand about the methods used for EIA studies
CO4 Discuss the implications of current jurisdictional and institutional arrangements in relation to EIA
CO5 Communicate both orally and in written form the key aspects of EIA
CO6 Understand how to liaise with and the importance of stakeholders in the EIA process
CO7 Access different case studies/examples of EIA in practice
CO8 Summarize the EIA report with suitable environmental management plan

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1				*				
CO2	*			*	*			
CO3				*	*			
CO4	*			*	*			*
CO5	*			*		*	*	*
CO6	*			*		*	*	*
CO7				*		*	*	*
CO8	*			*	*	*	*	*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Introduction to EIA	Definition – Principles of EIA – Short-term and Long-term objectives - Evolution of EIA worldwide and in India – Types of EIA - Projects subject to EIA (Category 1, 2 and 3) – Steps in EIA process – Objectives of the Standard Terms of Reference (TOR) - Stages and time frame for obtaining Environmental Clearance from MoEF & CC according to EIA notification 2006 – Merits and Demerits of EIA (K1, K2 & K3)	12

II	EIA Methodologies	Assessment of impacts: Air, water, soil, noise, biological, social, cultural, economic, and environmental factors – EIA Methodologies: Adhoc Method – Checklist Approach – Matrix Methods – Network Methods – Overlay Method (K2, K3 & K4)	10
III	Public Participation, Preparation and Review of EIA Report	Objectives of People's Participation - Advantages and Disadvantages of People's Participation - People's Participation Techniques: Public Hearing - Preparation and Review of EIA Report: EIA Reports Content - Basis and Criteria for Evaluation of EIA Reports and EIA (K2, K3 & K4)	8
IV	EIA case studies for major development projects	Major Highways Projects - Airport - River valley Projects – Mining and quarrying - Thermal and Hydroelectric Power Projects - Cement Industries (K3, K4, K5 & K6)	8
V	Environmental Management System	Environmental Management System**:** Core elements of EMS - Benefits of EMS - Certification body assessments of EMS - Documentation for EMS – ISO 14001 standard – PDCA (Plan-Do-Check-Act) in ISO 14001 Certification – Corporate Social Responsibility (CSR) Plan in India (K4, K5 & K6)	10

References

Text Books

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2. EIA Manual (2001) Ministry of Environment, Forest and Climate Change, New Delhi.

References

1. Anjaneyulu Y and Valli Manickam (2007) Environmental Impact Assessment Methodologies, 2nd Edition, B.S. Publications (ISBN: 978-81-7800-144-9).
2. Bregman JI (1999) Environmental Impact Statements. Lewis Publishers, London.
3. Eccleston CH (2000) Environmental Impact Assessment - A Comprehensive Guide to Project and Strategic Planning, John Wiley and Sons, NY.
4. Peter Wathern (2015) Environmental Impact Assessment: Theory and Practice, Taylor & Francis, London
5. Singleton R, Castle, P and Sort, D (1999) Environmental Assessment, Thomas Telford Publishing, London.
6. Whitelaw K and Butterworth (1997) ISO 14001: Environmental System Handbook.

Web Resources

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3. http://www.moef.nic.in/division/eia-manual
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CORE - X

ENVIRONMENTAL BIOTECHNOLOGY

Paper Code	19UPEVS3C10	Horus	L	T	P	Credit
Marks	100		4	1	-	5

Course Objectives:

The purpose of this course is to acquaint students with knowledge in environmental biotechnology for gene cloning, to apply the microorganisms for remediation of environmental pollutants, to develop skills in manipulating the microbial process for waste conversion and resource recovery, and to produce microbial bioproducts for environmental applications.

Course Outcomes:

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

CO1 Understand the basic principles and technologies of DNA and its manipulation, gene cloning and PCR techniques

CO2 Understand the basic principles and techniques of remediation of environmental pollutants

CO3 Explain the role of microbes in degradation of environmental pollutants

CO4 Acquire skills in manipulating the microbes for biodegradation of pollutants

CO5 Describe biotechnological solutions to address the waste bioconversion and microbial process to produce value added products.

CO6 Analyze reports in key areas of environmental biotechnology.

CO7 Apply the biotechnological process to recover resources from different wastes.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								
CO5								
CO6								
CO7								

ENVIRONMENTAL BIOTECHNOLOGY			
Unit	**Unit Title**	**Intended Learning Chapters (K1, K2, K3, K4, K5, K6)**	**Hours of Instruction**
I	Structure and DNA modifying enzymes	Introduction to Biotechnology - Organization of bacterial genome - Structure of DNA – Restriction enzymes: Nomenclature - Classification - restriction and Methylation - Type II restriction endonuclease - Use of restriction endonucleases - Restriction mapping and its applications - DNA modifying enzymes - nucleases - polymerases - DNA ligases. (K1, K2, K3)	8
II	Gene Cloning and PCR Techniques	Gene Cloning - Over view, Cloning vectors – Plasmids, phages and cosmids, phagemids, Ti plasmids and viral vectors M13 - Cloning strategies, cloning and selection of individual genes – PCR - Working principle, types and applications. Environmental genome. (K1, K2,K3)	8
III	Environmental Applications Microbes	Use of microbes in environmental decontamination - Biodegradation - Biosorption - Biotransformation – Bioaugmentation - Biostimulation - Phytoremediation, Mycoremediation - Phycoremediation - Bioleaching and Biomining - MEOR - Bioremediation pollutants: Heavy metals, PAHs, VOCs - Bioindicators and biosensors for detection of pollution. (K1, K2, K3)	12
IV	Biotechnology for waste management and Resource recovery	Biotechnology for waste management and resource recovery - sewage treatment - activated sludge process - Anaerobic treatment - sludge stabilization - aerobic composting, anaerobic digestion, biogas production, algal cultivation: nutrient removal. Solid waste treatment - biocomposting - vermicomposting - Air pollution control - bioscrubber, biofilters. (K3, K4, K5, K6)	12
V	Microbial Bioproducts	Microbial bioproducts for environmental cleanup - Microbial biomass - Biosorbents - Biosurfactants - Microbial enzymes: lignocellulases, lipases, dioxygenases - Bioflocculants - Bioplastics - Biofertilizers - Biopesticides - Microbial fuels: Bioethanol, Biobutanol, and Biohydrogen. (K4, K5, K6)	10

References

Text Books

1. P.K. Mohapatra (2008) Text Book of Environmental Biotechnology. IK International Publishers Ltd
2. Thakur, I.K. (2013) Environmental Biotechnology: Basic Concepts and Applications. 2nd edition.

Reference Books

1. Alexander N. Glazer Hiroshi Nikaido (1995) Microbial Biotechnology, WH Freeman and Company, NY, USA.
2. Bernaral R. Glick and Jack J. Pastemak (1994) Molecular Biotechnogy: Principles and Applications of Recombinant DNA, ASM Press. Washington, DC USA.
3. Brown TA (1995) Gene cloning – A introduction – Chapman & Hall, London.
4. Glazer and Nikaido (1995) Microbial Biotechnology. WH Freeman & Co., New York.
5. Kreuzer and Massey (2001) rDNA & Biotechnology. A guide for Teachers, 2nd Edition, ASM Press, Washington DC, USA.
6. Old RW and Primrose SB (1994) Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.
7. Primrose SB (1994) Molecular Biotechnology, 2nd edition, Blackwell Scientific Publications, UK.
8. Singh DP & SK Dwivedi (2005). Environmental Microbiology and Biotechnology. 1st Edition, New Age International (P) Ltd., Publishers, New Delhi.
9. Fulekar, M.H. (2010) Environmental Biotechnology, CRC Press.
10. Cheremisinoff, N.P. (1997) Biotechnology for Waste and Wastewater Treatment. Sciencedirect.

Web References

1. www.microbialfuelcell.org
2. www.pollutionissues.com/A-Bo/Bioremediation.html
3. www.bioreactors.net
4. http://enhs.umn.edu/current/5103/gm/harmful.html
5. www.wastewatertreatment.co.in/index.php
6. http://archive.industry.gov.au/Biotechnologyonline.gov.au/enviro/environment.html
7. https://preventioncdnndg.org/eco-quartier/biomethanization-2/
8. https://www.nrel.gov/workingwithus/learning.html
9. https://www.epa.gov/recycle/composting-home
10. https://www.epa.gov/remedytech/green-remediation-best-management-practices-bioremediation

CORE - XI

RESEARCH METHODOLOGY AND INSTRUMENTATION						
Paper Code	**19UPEVS3C11**		**L**	**T**	**P**	**Credit**
Marks	**100**	**Horus**	**4**	**1**	**-**	**4**

Course Objectives

The purpose of this course is to acquaint students about various types of research methods, instruments and their working principles, data process, report generation and to train the students to handle various research instruments.

Course Outcomes:

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

CO1 Know the types of research and scientific databases, report writing and plagiarism.
CO2 Chose the research that they want to carryout.
CO3 Identify and design their research problems.
CO4 Understand the principles of research methods and instruments required for their research experiments.
CO5 Apply their knowledge on instrumentation for environmental analysis, and field works and data collection.
CO6 Apply the Software's and Statistical analysis methods and Data interpretation.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2							*	*
CO3				*				*
CO4					*			*
CO5					*		*	*
CO6	*			*		*	*	

Unit	Unit Title	**Intended Learning Chapters (K1, K2, K3, K4, K5, K6)**	**Hours of Instruction**
I	Research Methods	Basics of Fundamental and Applied Research, Types, scope, hypothesis. (K1, K2) Concept of research articles, research papers, reviews, scientific popular articles; Components of a Research Article (title, author-line, address, abstract, summary, hypothesis, keywords, introduction, methodology, observations, discussion, conclusion, citing relevant work of others); Reference protocols ; Copyright Act (in brief), Plagiarism, Cheating / academic frauds; process of reviewing; Concept of Impact factor; H-Index, i-	8

		10 index and SCI Impact factor for journals. (K1, K2, K3)	
II	Basic Analytical Equipments	Principle, Working mechanism and environmental applications of pH Meter, Conductivity meter, Nephlometer. (K1, K2, K3) Basic principles and applications of light and electron microscopes. Types, function and applications of centrifuges. (K4, K5) Principle, types and environmental application of elctrophoretic techniques and radio immune assay techniques. (K4,K5)	8
III	Spectroscopy	Various ranges of electromagnetic radiation - Interaction of electromagnetic radiation with matter, Spectrophotometry - Principles and working mechanism, types and applications of colorimeter, UV - Visible spectrophotometer, fluorimeter, flame photometer, AAS, AES, ICP-MS, IR, NMR spectrophotometer and XRD spectrometer. (K3, K4, K5)	12
IV	Chromato graphy & Mass Spectrometry	Principle and concept of chromatography- stationary phase, mobile phase, partition and adsorption, coefficients. (K1,K2,K3) Working principle, instrumentation and environmental applications of Thin layer and Ion exchange chromatography, HPLC, HPTLC, LC-MS, and GC-MS 9 (K4, K5, K6)	12
V	Statistical Analyses	Statistical Analysis: Sampling Methods and Data Collection – Questionnaire Survey, Experiments and Field works. (K3, K4) Measures of central tendency: Mean, Median and Mode- Merits and demerits. Measures of dispersion: Range, Standard Deviation, Variance, Skewness and Kurtosis; Distribution- Normal, *t* test and *chisquare* test, Difference among means - ANOVA. (K3, K4, K5) Correlation and Regression - Linear and Multiple. Introduction to statistical Softwares (SPSS, R, MATLAB) (K3, K4, K5, K6)	10

References

Text Books:

1. Rt Kumar, (2010.) Research Methodology: A Step-by-Step Guide for Beginners, SAGE Pub.
2. Gurumani, N. (2006).Research Methodology for Biological Science. MJP Publishers.

References Books

1. Christian GD (2001), Analytical Chemistry, 5th edition, John Wiley and Sons Inc., India
2. Khopkar SM (1993) Environmental Pollution analysis, Wiley Eastern Ltd.
3. Manahan SE (2007) Environmental Chemistry, 7th edition, Lewis Publications, Florida, USA.
4. Banerjee PK (2004) *Introduction to Biostatistics*. S. Chand and Co., New Delhi.

5. Manly, Bryan FJ (2001) Statistics for Environmental Science and Management, Chapman and Hall / CRC Press, Boca Raton, FL, USA.
6. Skoog DA, Holler FJ and Nieman TA (1980) Principles of Instrumental Analysis –5th edition, Thomson Asia Pvt., Singapore.
7. Vogel AI (1998) Quantitative Analysis, 6th edition, Prentice Hall Inc., Willard HH, Merrit LL and Dean JA (1976) Instrumental Methods of Analysis, 5th edition, Van Nostrand Reinhold.
8. Rastogi VB (2007) *Fundamentals of Biostatistics*. Ane Books India, New Delhi.
9. Wilson, K, Walker, J (2010) Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University Press.

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2. www.computerhope.com/os.htm
3. http://www.fao.org/docrep/005/ac665e/ac665e05.htm#TopOfPage
4. http://www.rss.hku.hk/plagiarism/page2s.htm
5. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/bes2.1258
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8. https://www.epa.gov/sites/production/files/2015-05/documents/402-b-04-001b-14-final.pdf
9. https://en.wikibooks.org/wiki/Proteomics/Protein_Identification_-_Mass_Spectrometry/Types_Mass_Spectrometry

SEMESTER - IV

CORE - XII

ENVIRONMENTAL LAW AND POLICIES

Paper Code	19UPEVS4C12	Horus	L	T	P	Credit
Marks	100		4	1	-	4

Course Objectives

The purpose of this course is to introduce the students to the vast field of Laws and Policies both at the national and international level relating to environment.

Course Outcomes

CO1 Understand environmental legislation and policies of national and international regime.
CO2 Have an insight into major acts and rules applicable for pollution control and natural resource conservation.
CO3 To develop the skills needed for interpreting laws, policies and judicial decisions about the environment.
CO4 Know regulations applicable to industries and other organizations with significant environmental aspects.
CO5 Apply the legislation concepts for solving the local environmental problems.
CO6 Get knowledge of the legal system operating in India.
CO7 Be in a position to prepare compliance reports for getting environmental clearance
CO8 Prepare the environmental management system for an organization.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1				*		*		
CO2				*				
CO3						*		*
CO4				*		*		
CO5						*		
CO6							*	
CO7				*				*
CO8						*		*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Environmental Protection**	Indian Constitution – Structure – Provisions for environmental protection – Indian environmental lAw – Framework and Implementation - Role of International Environmental Agencies -UNEP, GEF, UNFCC and IPCC**(K1, K2)**	5
II	**Environmental Laws in India**	Indian Wildlife (Protection) Act, 1972; Forest Conservation Act 1980; Indian Forests Act (Revised) 1982; Water (Prevention and Control of Pollution) Act, 1975; Air (Prevention and Control of Pollution) Act 1981,	10

		1987 and Rule 1982; Environment (Protection) Act, 1986 and Rules 1986; ; National Environment Appellate Authority Act, 1997; Biodiversity Act 2002; National Green Tribunal Act 2010 **(K1, K2)**	
III	**Guidelines and Rules for Environmental Protection in India**	Bio-Medical Waste (Management & Handling) Rules,1998; Recycled Plastics Manufacture and Usage Rules, 1999; Noise Pollution (Regulation and Control) Rules, 2000; Municipal Solid Waste (Management and Handling Rules) 2000; The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules,2008; Wetland Rules 2009; Coastal Regulation Zones (CRZ) Rules 2011; E-waste Management and Handling Rules 2011; Plastics Manufacture, Sale and Usage Rules, 2011. **(K1, K2)**	10
IV	**International Environmental Treaties and Conventions**	Stockholm Conference on Human Environment,1972; Ramsar Convention on Wetlands, 197; Montreal Protocol, 1987; Basel Convention (1989,1992); Earth Summit at Rio de Zaneiro,1992; Kyoto Protocol, 1997; Earth Summit at Johannesburg, 2002; , Copenhagen Summit 2009 and 2019. Paris Agreement, 2016.SDG - 2030 **(K1, K2)**	10
V	**Major Initiatives/Policies from MoEF**	National Policies for Environmental Protection in India: National River Conservation Plan (NRCP), National Ganga River Basin Authority (NGRBA), Ganga Action Plan Phase I and II, Green India Mission – Environmental Clearances: National Environmental Assessment and Monitoring Authority (NEAMA)**(K4)**	10

References

Text Books

1. Environmental Law in India (2000) P. Leelakrishnan Butterworths India Publishers
2. Textbook on Environmental Law (2010) N. Maheshwara Swamy, Asia Law House Publishers

Reference Books

1. Gurudeep Singh (2005) Environmental Law in India, McMillan, New Delhi.
2. ShyamDiwan and Armin Rosencrany (2001) Environmental Law and Policy in India, Oxford University Press, New Delhi.
3. Singh G (1995) Environmental Law: International & National Perspectives.
4. Tamil Nadu Pollution Control Board (1999) Pollution Control Legislation Vol. I and II, Chennai.

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2. www.tnpcb.gov.in/
3. www.thesummitbali.com/
4. envfor.nic.in/legis/legis.html
5. edugreen.teri.res.in/explore/laws.htm
6. envfor.nic.in/legis/crz/crznew.html
7. rti.gov.in/
9. www.ngosindia.com/resources/pil.php

CORE - XIII

ENVIRONMENTAL HEALTH AND SAFETY

Paper Code	19UPEVS4C13	Horus	L	T	P	Credit
Marks	100		4	1	-	5

Course Objectives

Introduction to basic principles of environmental health and safety practices and creating awareness of public and occupational health and safety requirements associated with the environment. The purpose of this course is to understand the role of environmental health, protection, safety at work, occupational health and safety, compliance and best practices.

Course Outcomes

CO1 Knowledge in the concepts and scope, Basic requirements for healthy environment, Environmental quality, human exposure and health impact.

CO2 Knowledge of the Industrial pollution and chemical safety in public exposure from industrial sources, Hazards by industry major chemical contaminants at workplace. Industrial environmental accidents.

CO3 Knowledge of understand the Environmental Disease present study in Fluorosis and Allergies; Epidemiological issues.

CO4 Knowledge of understand course will equip student with basic knowledge on safety issue related with explosion, pollutant release in water and air, and to implement measure during outbreak of flu epidemic at work place.

CO5 Knowledge of understand of occupational Safety and Health. Principles and methods of occupational health, Health problem due to industrial dust, heat, chemicals, noise, toxic gases and metals, Health hazard in agriculture - Pesticides and environment, Pesticides and human health.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*	*	*	*		*	*	
CO2		*	*		*			*
CO3	*	*	*		*		*	
CO4	*			*		*	*	*
CO5		*	*		*			
CO6	*	*	*	*	*	*	*	*

Unit	Unit Title	Intended Learning Chapters (K1, K2,K3,K4,K5,K6)	Hours of Instruction
I	**Environmental Health**	Concept and scope; Global and regional perspectives; Basic	8

		requirements for healthy environment; Environmental quality, human exposure and health impact – impact of environmental factors on human health (K1, K2)	
II	**Industrial Pollution and Chemical Safety**	Extent of industrial pollution, Public exposure from industrial sources, Hazards by industry, Major chemical contaminants at workplace, Industrial environmental accidents (K2, K3, K4)	**12**
III	**Environmental Diseases**	Asbestosis, Silicosis, Sycosis, Asthma, Fluorosis and Allergies; Epidemiological issues - Malaria and Kala –azar (K4, K5)	**10**
IV	**Occupational Safety and Health**	Occupational hygiene/ safety and disease; Principles and methods of occupational health, Health problem due to industrial dust, heat, chemicals, noise, toxic gases and metals, Health hazard in agriculture (K4) - Pesticides and environment, Pesticides and human health. (K5, K6)	**10**
V	**Environmental Health Hazard and Risk Assessment**	Hazard and risk, Biological, chemical, physical and psychological health hazard; Health risk assessment and management (K4, K5)	**12**

References

Text Books

1. Shaw, J. Chadwick (1998) Principles of Environmental Toxicology,Taylor& Francis Ltd
2. AnnaleeYassi, TordKjellstr"om, Theo de Kok, Tee Guidotti (2001). Basic Environmental Health, Oxford University Press

Reference Books

1. Environmental Health- Monroe T. Morgan (2003).
2. Handbook of Environmental Health and Safety - Koren, H. (2002).
3. Institution of Occupational Safety and Health, United Kingdom- A Practical Guide, 1993.

Journals and Documents

1. www.ehs.ucsb.edu/
2. www.ifc.org/ehsguidelines
3. www.slintec.lk/wp-content/uploads/2011/08/HealthSafetyManual.pdf

ELECTIVE COURSES

ELECTIVE COURSE - I

ENERGY RESOURCES AND ENVIRONMENTAL SUSTAINABILITY

Paper Code	19UPEVS1E01	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives

The purpose of this course is to understand the various forms of conventional energy resources. The present energy scenario and the need for energy conservation, to explain the concept of various forms of renewable energy. Outline division aspects and utilization of renewable energy sources for both domestics and industrial application and to analyses the environmental aspects of renewable energy resources.

Course Outcomes

CO1 Knowledge in the concepts of Energy sources, Environment and Sustainable Development, Energy sources; Biological processes; quality and concentration of energy sources; Renewable resources.

CO2 Knowledge of the Non-renewable Energy Sources and Thermodynamics; Energy conversion, Global Energy crisis, Composition and Classification of coal, crude oil and natural gas and Environmental impacts of fossil fuel consumption.

CO3 Knowledge of understand of Principals of generation of hydroelectric power, Ocean thermal energy conversion, Energy use pattern in different parts of the world and Management of renewable energy.

CO4 Knowledge of understand the green energy technologies, environmental leap-fogging; Eco-green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity.

CO5 Knowledge of life supporting systems, biodiversity and ecosystem services and their implications for sustainable development.

CO6 Knowledge of global warming, greenhouse gas emissions, mitigation and adaptation, clean/green energy technologies, United Nations Framework Convention on Climate Change (UNFCC); sustainable development.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*	*		*	*			
CO2		*						
CO3			*	*	*	*		
CO4						*		
CO5			*		*			
CO6								

Unit	Unit Title	Intended Learning Chapters (K1, K2,K3,K4,K5,K6)	Hours of Instruction
I	**Energy sources**	Introduction to nexus between Energy, Environment and Sustainable Development; Energy transformation from source to services; Energy sources, sun as the source of energy(K1, K2); biological processes; photosynthesis; food chains, classification of energy sources, quality and concentration of energy sources; fossil fuel reserves - estimates, duration; theory of renewability, renewable resources; overview of global/ India's energy scenario. (K1, K2 & K3)	10
II	**Thermodynamics and Non-renewable Energy Sources**	First and second laws of thermodynamics – Energy conversion – Global Energy crisis - Non-renewable energy sources: Fossil fuels (K1, K2) – Composition and Classification of coal, crude oil and natural gas – Consumption and demands of coal, crude oil and natural gas – Environmental impacts of fossil fuel consumption (K3,K4)	10
III	**Renewable Energy Sources**	Solar energy, geothermal, tidal, wind energy - Principals of generation of hydro-electric power - Ocean thermal energy conversion (K3,K4) - Energy use pattern in different parts of the world - Management of renewable energy - Present scenario of renewable energy sources in India (K4,K5, K6)	12
IV	**Green Innovation & Sustainability**	Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation-, technological/ environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity(K4,K5)-WEHAB(eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies); design for sustainability (D4S). (K5, K6)	12

V	**Green Energy and Sustainable Development**	The inseparable linkages of life supporting systems, biodiversity and ecosystem services and their implications for sustainable development (K3,K4); global warming; greenhouse gas emissions, impacts, mitigation and adaptation; future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability - United Nations Framework Convention on Climate Change (UNFCC); sustainable development. (K4,K5, K6).	10

References

Text Books

1. Boyle GF (2004) Renewable Energy - Power for a Sustainable Future, Second edition, Oxford University Press, UK.
2. Glyll Henry and Gary W. Heinke (1996) Environmental Science and Engineering Pearson Education, New Delhi.

Reference Books

1. Energy Science: Principle, Technologies, and Impacts - Oxford University Press, UK.- John Andrews and Nick Jelly (2007).
2. Essential of Environmental Studies, Pearson Education, New Delhi- Kurian Joseph and Nagendra R (2004).
3. Environmental Chemistry. Goel Publishing House, Meerut- Sharma BK and Kaur SH (1992).
4. Environmental Science -10th Edition, Thomson Asia Pvt. Ltd. Publications, Singapore- Taylor and Miller (2008).
5. An Introduction to Energy Sources- Indian Institute of Technology- Viswanathan B (2006).

ELECTIVE COURSE – II

ECO-TOURISM AND WILD LIFE MANAGEMENT

Paper Code	19UPEVS1E02	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives

To know about the concept of ecotourism, development of ecotourism places. To know about the impacts and management issues of ecotourism.

Course Outcomes

CO1 Know the principles and concept of ecotourism.

CO2 Able to understand the types and benefits of ecotourism

CO3 Know interesting places of ecotourism

CO4 Evaluate the impacts of ecotourism on the environment

CO5 Understand the need for wildlife conservation

CO6 Relate wildlife resources with Ecotourism

CO7 Acquire the knowledge on management of Ecotourism

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*				*			
CO2					*			
CO3					*			
CO4						*		
CO5					*			
CO6				*				
CO7								*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Introduction to Eco-Tourism**	Principles of Ecotourism – Types of Ecotourism – Concepts of Ecotourism – Origin of Ecotourism – Objectives of Ecotourism – Benefits of Ecotourism – Trends affecting Ecotourism. Concepts of Tourism - Classification – Religious Tourism – Cultural Tourism – Heritage Tourism – Monumental Tourism – Adventure Tourism – Mass Tourism – Sustainable Tourism – Consumptive and NonConsumptive Tourism **(K1, K2)**	7
II	**Interesting**	Places of interests of Ecotourism – Ecocircuit of the Western Ghats – Infrastructural facilities for Ecotourism –	10

	Eco-tourism	Maintenance of Ecological Centers – Important Biosphere Reserves. Target group of Ecotourism – Ecotourism and Conservation – Study of different Ecosystem – Rain forest Ecotourism – Mountain Ecotourism – Polar, Islands and Coasts Ecotourism – Wilderness – Marine Ecosystem. **(K2, K5, K6)**	
III	**Impact of Eco-tourism**	Impact of Ecotourism – Economic Impacts (Fiscal Impacts, Concept and Methods) – Types and Degree of Impacts from Ecotourism activities – Socio-cultural Impacts – Ecotourism related organization – Ecotourism Research - Disasters and Ecotourism **(K5, K6)**	10
IV	**Wildlife Conservation**	Wildlife conservation - Protected Areas Network in India - Goals of management, Strategies for planning. Factors influencing wildlife management such as habitats, population, behaviour, food habits, health, etc. - Tools for data collection and analysis.**(K1, K2, K3)**	10
V	**Wildlife Management**	Human land-use and wildlife management units - Important projects for the conservation of wildlife in India - Role of local communities in wildlife management – Man-wildlife conflicts - Poaching of wildlife - Wild life conservation laws - The Wildlife (Protection) Act, 1972 (2002 amendment). **(K4, K5, K6)**	7

References:

Text Books

1. Dasman RF (1968) Environmental Conservation: John Wiley and Sons, New York.
2. Mukherjee N (2008) Ecotourism and sustainable Development. Cybetech Publications, New Delhi.

Reference Books

1. Prabhas Chandra (2003) Global Ecotourism, Kaniskha Publishers, New Delhi.
2. Sinha, P.C (2003) Encyclopedia of Ecotourism, Volume I, II and III, Anmol Publications Pvt. Ltd., New Delhi.
3. Weaver DB (2001) The Encyclopedia of Ecotourism, CABI Publishing, UK.

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2. www.nativescience.org/html/eco-tourism.html
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4. envfor.nic.in/divisions/9-10.pdf
5. http://www.ceeraindia.org/documents/lib_tabofcon_160300.htm

ELECTIVE COURSE – III

ENVIRONMENTAL NANOTECHNOLOGY

Paper Code	19UPEVS1E03	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives:

The purpose of this course is to provide background, principles, development of nanomaterials and their applications pertaining to remediation of environmental contaminants, water purification, and to understand the impact of nanomaterials on environment.

Course Outcomes:

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

CO1 Understand the background about on nanotechnology and its importance
CO2 Understand different types of nanomaterials and their use
CO3 Obtain knowledge on synthesis the nanomaterials by different methods
CO4 Acquire knowledge on characterization and properties of the nanomaterials
CO5 Understand the application nanomaterials for degradation of environmental pollutants
CO6 Acquire knowledge and skills in nano remediation, and water purification
CO5 Understand the impact of nanomaterials on environment.

Mappings of course outcomes with programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2		*						
CO3		*						
CO4			*					*
CO5			*					
CO6		*	*					*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Introduction to Nanotechnology	Introduction to Nanoscience and Nanotechnology - Nanoscale Properties - Electrical, Optical, Chemical - Engineered Nanomaterials - Carbon based nanomaterials (K1,K2) - Fullerins, Carbon Nanotubes; Metal based Nanomaterials - Metal and Metal oxide Nanoparticles; Dendrimers - Nanocomposites - Nonporous materials. (K1, K2)	6
II	Synthesis of Nanomaterials	Introduction to synthesis of nanomaterials - Bottom-up approach - Top-down approach - Physical methods - ball milling, melt mixing, physical vapour deposition, sputter deposition, evaporation; Chemical methods - chemical	10

		reduction, sol-gel method, photochemical synthesis, electrochemical synthesis, emulsion synthesis, sonochemical methods, microwave assisted synthesis; Biological methods - Green synthesis of nanoparticles using Bacteria - Fungi -Actinomycetes- Plants and plant metabolites. (K1, K2, K3)	
III	Characterization of Nanomaterials	Nanomaterials characterization using Spectrometer - UV-Vis, FT-IR, Fluorescence Spectrophotometer, Raman Spectroscopy; Electron Microscopy - TEM, SEM, Cryo-SEM, Scanning Probe Microscopy (AFM, STM), Confocal Microscopy, Diffraction Techniques (XRD, Synchrotron). (K2, K3, K4)	10
IV	Environmental Applications of Nanomaterials	Nanomaterials for environmental remediation – Nanoscale zero-valent iron (NZVI), Titanium dioxide nanoparticles - Bimetallic nanoparticles - Silver nanoparticles - Metal oxide nanoparticles - Nanoadsorbents - Nanocatalysts - Nanoflocculant. Degradation and transformation of environmental pollutants - Halogenated Organic Solvents, Persistent Organic Pollutants, PPCPs, dyes, explosives, toxic heavy metals - arsenic and chromium. Nanoremediation - Ground Water Remediation - Permeable Reactive Barrier - Air purification - Soil remediation. (K3, K4, K5, K6)	12
V	Nanotoxicology and Environmental Impacts	Routes of nanomaterials into the water environment, Hazardous effects of nanomaterials on Human and Animal Health (K1, K2). Impacts of nanomaterials on environmental microbial community - bioaccumulation - cytotoxic - genotoxic - effects of engineered nanoparticles. (K4, K5)	6

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ELECTIVE – IV

ENVIRONMENTAL ENGINEERING

Paper Code	19UPEVS1E04	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives:

The purpose of this course is to teach the students about the background of engineering principles, designs and methods to solve the environmental problems like wastewater treatment, sludge stabilization and biogas production, and to monitor environmental pollutants.

Course Outcomes:

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

CO1 Understand the complex environmental issues use of various engineering strategies to apply to solve environmental issues
CO2 Understand the basic principles and methods of environmental engineering
CO3 Identify the suitable treatment methods for wastewater treatment and sludge stabilization
CO4 Understand the process of biogas production from sewage sludge.
CO5 Use their acquired knowledge to design the reactors for sewage and sludge treatment.
CO6 Monitor the environmental pollutants and control the treatment process

Mapping with Programme Outcomes:

The mapping of course outcomes with programme outcomes are tabulated as follows.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2		*						
CO3			*	*				
CO4			*					
CO5							*	
CO6				*		*		*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	An Overview of Wastewater Treatment and Disposal	Environmental sanitation, wastewater - wastewater quantity and quality-characteristics - treatment required - preliminary, primary, secondary, and tertiary treatments - sedimentation - effluent disposal - chlorination - sludge stabilization - biosolids. (K1, K2) Sewer system - design of sewers, estimation of sewage flow, sewage collection, and odour control. (K3, K4)	10

II	Pre and Primary Wastewater Treatment Plant	Principle and design of screening, equalization tank, grit chambers, rectangular and circular coagulation and flocculation tank, sedimentation tank. Chemically Enhanced Primary Treatment (CEPT) - Design for a Small Community level. (K2, K3, K5, K6)	8
III	Aerobic Treatment of Wastewater	Principles and design of aerobic biological treatment of sewage - Activated sludge process, Oxidation Ditch, Aerobic lagoons, Trickling filters, Sequencing batch reactors, Fluidized-bed bioreactors - Nutrient removal and pathogen reduction. (K2, K3, K5, K6)	8
IV	Anaerobic Treatment of Wastewater and Sludge	Design of facilities for anaerobic treatment of wastewater and sludge (K5) - Anaerobic digesters and septic tanks, Anaerobic filters, Upflow anaerobic sludge blanket reactor - Sludge thickening and digestion -Biogas production - Sludge dewatering process, Biosolids - drying and disposal. (K5, K6)	10
V	Air Pollution and Control Equipments	Principle and design of minimum stack height - Settling chamber - Cyclone collector - Fabric filter and Electrostatic Precipitators (ESP) - Bioscrubbers. (K4, K5, K6)	8

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4. http://onsite.tennessee.edu/Aerobic%20Treatment%20&%20ATUs.pdf
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7. https://engineeringonline.ucr.edu/blog/what-are-advanced-water-treatment-processes/
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9. https://www.diva-portal.org/smash/get/diva2:808135/FULLTEXT02.pdf
10. https://www.host.nl/en/biogas-plants/sludge-treatment/

ELECTIVE COURSE – V

ENVIRONMENTAL ECONOMICS

Paper Code	19UPEVS1E05	Horus	L	T	P	Credit
Marks	100		3	1	-	4

Course Objectives The purpose of this course is to introduce different aspects of the sub-discipline of environmental economics to the students and enable them to understand the economics of the relationship between economic activities and environmental impacts

Course Outcomes

CO1	Aware of the concepts of environmental economics.
CO2	Know the macro and micro issues and their impact.
CO3	Acquaint adequate knowledge on sustainable development concept.
CO4	Understand the impact of economic growth on environment
CO5	Know the concept of natural resource economics
CO6	Understand the process of cost benefit analysis
CO7	Know the valuation, monitoring and enforcement methods.
CO8	Understand various laws and policies for environmental economics.

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1				*				
CO2				*				
CO3						*		
CO4				*		*		*
CO5	*					*		
CO6						*		*
CO7								
CO8				*		*		

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Environmental Economics**	Meaning and Central Themes of Environmental Economics, Ecology- Environment and Economy Perspectives, Environment and Economy Linkages, Current State of Environment, Sustainable Development: Basic Issues, Concepts, Definitions Approaches, Rules and Indicators. **(K1, K2)**	8
II	**Micro and Macro economics**	Externality, Public goods, Asymmetric Information, Environmental problem as an Externality, Environmental Conservation as a Public Good, Correcting Market Failures, Concepts on Green National Income Sustainable Development - Weak notion - Strong Notion, Practising Sustainable Development. **(K1,K2, K3)**	5
III	**Cost-Benefit Analysis and Environment**	Damage and Benefit Estimation: Background and Introduction, Some objections to CB Analysis Benefit "Routes" – A Brief Review, Demand shifts: Complementarity, Cost Shifts: Averting, Replacing or Curing Expenditure, Travel Cost and Its Relation to Environmental Quality, Hedonic Pricing, Direct Methods of Benefit Estimation **(K3, K4)**	7
IV	**Economics of Natural Resources**	Natural Resources and the Economy, Natural Resource Scarcity-a Historical Perspective Economics of Natural Resource Exploitation, Economic Analysis of Non-Renewable and Renewable Natural Resources; Common Property Management Open access and community management, Coordination problem - Folks Theorem - Privatisation of the Natural Resources. **(K4,K5)**	7
V	**Environmental valuation, monitoring and enforcement**	Theory of Environmental Valuation- Introduction to Methods of Valuation. Theory of Regulation and instruments of Regulation, Elements of a Monitoring and Enforcement System Economics of Monitoring and Enforcement, Major Laws and policies for enforcement.**(K5,K6)**	5

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3. Hanley, Shogren and White (1997), Environmental Economics in Theory and Practice, Macmillan India Ltd.(and Oup Edition).
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SUPPORTIVE COURSES

SUPPORTIVE COURSE - I

ECOLOGY AND ENVIRONMENT

Paper Code	19UPEVS1S01	Horus	L	T	P	Credit
Marks	100		3	-	-	3

Course Objectives

The purpose of this course is to introduce and provide basic knowledge on the concept and principles of Environmental science, ecology and ecosystems, and to give adequate knowledge on natural resources, biodiversity and their conservation.

Course Outcomes

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

CO1	Understand the basic concepts and functions of environment, ecology and ecosystem
CO2	Understand the different environmental compartments and their structure and functions in ecosystem
CO3	Obtain more knowledge about population ecology and their inter and intraspecific relationships
CO4	Understand the significance and need for environmental protection and sustainability
CO5	Adequate knowledge on the status of available natural resources and biodiversity and its conservation principles

Mapping course outcomes with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*							
CO2	*							
CO3	*							
CO4	*		*			*		*
CO5	*					*		*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Introduction	Environmental Science - Definition, Scope and Importance - *Components of the environment*: Atmosphere, Hydrosphere, Lithosphere and Biosphere – Structure and composition - History and scope of Ecology - Terminologies in ecology (K1, K2 & K3)	8
II	Ecosystem	Types of ecosystems – Terrestrial and aquatic ecosystems, Structure and functional aspects of ecosystem - Food Chain, Food Web, Energy flows, Ecological pyramids - Productivity of an ecosystem - Biogeochemical cycling - Ecological succession (K1, K2 & K3)	10
III	Population Ecology	Population ecology - Levels of Organization, population characteristics - density, natality, mortality, survivorship curves, age distribution, growth curves and models - Population interactions - Co-evolution, Neutralism, symbiosis, commensalism, mutualism, antagonism, antibiosis, parasitism, predation; competition- inter and intra specific (K1, K2 & K3)	10
IV	Natural Resources	Classification and significance of natural resources – Soil, forest, water, wildlife and minerals - Concepts and approaches of natural resource conservation - Natural resources of India - Legal provisions to conserve natural resources in India (K2, K3 & K4)	8
V	Biodiversity	Types of Biodiversity - Species, Genetic, Community and Ecosystem diversity Megadiversity zones and Hot Spots (K2 and K4) - Biodiversity *Conservation*: *In situ* and *Ex situ* conservation measures - *Use of Biodiversity:* Food, medicine, raw material, aesthetic and cultural value – Bioprospecting (K3, K4 & K5)	9

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2. Eugene P. Odum and Gary W. Barrett. (2004). Fundamentals of Ecology (5th Edition) Brooks/Cole Publishers.
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2. Muthuchelian K (2013) Glimpses of Animal Biodiversity, Astral International (P) Ltd., New Delhi.
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SUPPORTIVE COURSES - II

ENVIRONMENTAL POLLUTION

Paper Code	19UPEVS1S02	Horus	L	T	P	Credit
Marks	100		3	-	-	3

Course Objectives:

The purpose of this course is to gain awareness of environmental pollution and its types, sources, effects, monitoring & control techniques, and to understand the fundamental principles governing the interactions between transport of pollutants in the environment.

Course Outcomes

CO1	Learn about the air, water and soil pollutants, sources and its effects
CO2	Have clear understanding on the air, water, noise and radiation standards and its techniques
CO3	To understand the type impacts on environment from each of the pollutant
CO4	Apply relevant techniques, skills and modern engineering tools to solve the environmental problems

Mapping course outcomes with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1		*						
CO2				*				
CO3		*		*				
CO4		*	*	*				*

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Environmental Pollution**	Environmental pollution – Types (K1& K2), causes and effects (K3) - Sources of pollution – Point and non-point sources (K2 & K3) - Classification of pollutants (K3) - Contaminant types - Control measures and management perspectives for environmental pollution (K4 & K5)	6
II	**Air Pollution**	Air pollution - Natural and anthropogenic sources of pollution (K1 & K2) - Primary and secondary pollutants (K3) - Transport and diffusion of pollutants - Behavior of pollutants in the atmosphere (K3 & K4)– Effects on environment - Methods of monitoring and control of air pollution - SO_2, NOx, CO, SPM (K3, K5 & K6).	8

III	**Water Pollution**	Water pollution – Types, sources and consequences of water pollution (K2 & K3) - Physico-chemical and bacteriological sampling (K3 & K4)- Water quality and standards - Sewage and wastewater treatment and recycling(K4). *Marine Pollution*: Sources of marine pollution and its control (K2 & K4) - Effects of pollutants on human beings, plants, and animals (K3 & K4)	8
IV	**Soil Pollution**	Soil pollution - chemical and bacteriological sampling as analysis of soil quality (K3 & K4) - Effects and remediation techniques for Soil pollution 9K4 & K5)	6
V	**Noise, Thermal & Radiation Pollution**	Noise pollution - Sources of noise pollution (K1 & K2) - Measurement and indices (K4)– Effects and Control measures(K3 & K4). *Thermal Pollution* – Sources & Effects(K2 & K4). *Radiation Pollution* – Sources, Measurement, Units and control techniques (K2 & K4)	6

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5. www.noisecontrol.com/the-common-causes-of-noise-pollution
6. www.conserve-energy-future.com/causes-and-effects-of-soil-pollution.php

SUPPORTIVE COURSES - III

ENVIRONMENTAL HEALTH AND SAFETY

Paper Code	19UPEVS1S03	Horus	L	T	P	Credit
Marks	100		3	-	-	3

Course Objective

The purpose of this course is to understand the role of environmental health, protection, safety at work, occupational health and safety, compliance and best practices.

Course outcome

After completing this course, students will be able to:

CO1: Understand the importance of maintaining a safe workplace, safety standards and with regulatory requirements.
CO1: Acquire knowledge on the industrial pollution and environmental diseases.
CO2: Understand the workplace injury, its prevention, risk management, incident investigations and the role of safety in the business community.
CO3: Understand the acute and chronic health effects of exposures to chemical, physical and biological agents in the workplace.
CO4: Demonstrate knowledge of different types of exposure and biological effects, exposure guidelines and basic workplace monitoring
CO5: Understand the significance occupational health, its issues and risk assessment.

Mapping course outcomes with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	*			*				
CO2		*						
CO3		*		*				
CO4		*					*	
CO5	*			*			*	

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Environmental Health	Concept and scope; Global and regional perspectives; Basic requirements for healthy environment; Environmental quality, human exposure and health impact – impact of environmental factors on human health. (K1, K2)	5
II	Industrial Pollution and Chemical Safety	Extent of industrial pollution, Public exposure from industrial sources, Hazards by industry, Major chemical contaminants at workplace, Industrial environmental accidents (K1, K2)	8
III	Environmental Diseases	Asbestosis, Silicosis, Sycosis, Asthma, Fluorosis and Allergies; Epidemiological issues - Malaria and Kala -azar (K, K2, K4)	7
IV	Occupational Safety and Health	Occupational hygiene/ safety and disease; Principles and methods of occupational health, Health problem due to industrial dust, heat, chemicals, noise, toxic gases and metals, Health hazard in agriculture - Pesticides and environment, Pesticides and human health. (K, K2, K4)	7
V	Environmental Health Hazard and Risk Assessment	Hazard and risk, Biological, chemical, physical and psychological health hazard; Health risk assessment and management. (K5, K6))	5

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2. AnnaleeYassi, TordKjellstr"om, Theo de Kok, Tee Guidotti (2001). Basic Environmental Health, Oxford University Press

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SUPPORTIVE COURSES - IV

GLOBAL ENVIRONMENTAL ISSUES AND MANAGEMENT

Paper Code	19UPEVS1S04	Horus	L	T	P	Credit
Marks	100		3	-	-	3

Course Objectives

To focus on major global environmental issues including population explosion, biodiversity loss, pollution, energy use, climate change and best environmental technologies for a sustainable development. To know how they are managed in various settings around the world.

Course Outcome:

CO1	Clearly identify important global, national, and local issues relating to population, food, and the environment
CO2	Explain the causes and consequences of the issues identified above
CO3	Communicate environmental issues in a professional manner
CO4	Understand how to work in a team in a scholarly and professional setting

Mapping course outcomes with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1				*		*		
CO2				*				
CO3						*		*
CO4				*		*		

Syllabus:

Unit	Unit Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	**Human Population and Environment**	Basic demographic concepts: Growth, fertility, mortality and migration - Overview of population growth – Population distribution and Urbanization - Poverty, food security and environmental degradation – Development vs Environment. **(K1, K2)**	5
II	**Global Atmospheric Changes**	Global Air Quality and CO_2 concentration scenario - Role of air pollutants in climate change – Sources of greenhouse gases - Ozone depleting substances – Facts and figures of current global warming scenarios in the world - El Niño and La Niña – Global consequences of El Niño**(K1, K2)**	10
III	**Overexploitation of Biological Resources**	Overexploitation of natural resources: Ecological footprint – Earth Overshoot Day - Water resources: Status of groundwater quality in India –	10

		Desertification. Soil Resources: Global threats for soil quality - Loss of organic carbon. Biodiversity Resources: Biodiversity Hot spots in India – Bioprospecting – Factors influencing biodiversity loss. . **(K1, K2)**	
IV	**Global Disaster Episodes**	Geological Disasters: Earthquake: Origin of Earthquake, its magnitude and intensity - Earthquake prone zones in India - Effects of earthquake. Volcanoes: Types of volcanic eruptions - Active volcanic belts in the world - Nature and magnitude of volcanic hazards. Hydrological hazards: Flash flood - Flood management strategies - Regions of flood prone zones in India – Flood forecasting and warning – Man -made disasters: Oil spills – Forest fire -. **(K1, K2)**	10
V	**Sustainable Environmental Management**	Utilization of renewable energy resources – Solar, Wind, Hydroelectric and Biomass energy resources – Phytotechnologies for soil and water decontamination programmes – Sustainable agricultural practices (Biofertilizers and Biopesticides) – National Action Plan on Climate Change (Eight missions) – Recent initiatives related to climate change adaptation and mitigation in India - The Global 200: Priority Ecoregions for Global Conservation – UNDP Sustainable Development Goals 2030 Agenda. **(K4)**	10

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1. Frances Harris (2012) Global Environmental Issues, 2nd edition, John Wiley & Sons Ltd., UK.
2. Stavros G. Poulopoulos and Vassilis J. Inglezakis (2016) Environment and Development: Basic Principles, Human Activities, and Environmental Implications. Elsevier, Netherlands.

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