Annexure-V

CENTRAL UNIVERSITY OF RAJASTHAN

DEPARTMENT OF ENVIRONMENTAL SCIENCE

SCHOOL OF EARTH SCIENCES

LIST OF PROGRAMMES OFFERED BY THE DEPARTMENT OF ENVIRONMENTAL SCIENCE

A. Integrated M.Sc. Environmental Science (5 Years)
B. M.Sc. Environmental Science (2 Years)
C. Ph.D. Environmental Science

A. INTEGRATED M.Sc. ENVIRONMENTAL SCIENCE (5 YEARS)

Program Objectives

1. Integrate environmental science with other disciplines for ecologically sustainable development.
2. Motivate students for environmental protection and improvement.
3. Develop an attitude of concern for the environment.

Program Outcomes

On completing the program, students will able to:

1. Understand the basic concepts, principles, and methods related to the environment with knowledge support from other disciplines.
2. Use various state-of-the-art tools and techniques in the field of environmental monitoring and assessment
3. Acquire knowledge of socio-economic impacts of environmental problems
4. Serving to various sectors of academia, research, industries, and consultancies.

Central University of Rajasthan
School of Earth Sciences
M.Sc. Integrated Environmental Science (3+2 = 5 years)
Course Structure

Semester III

S. No.	Course Code	Subject	Credit
1	ENV201	**Environmental Studies**	3
		Biology	4
		2 courses (Maths, Physics, Chemistry, Computer Science, Statistics, Economics)	4+4
		Social Science	3
			18

Semester IV

S. No.	Course Code	Subject	Credit
1	ENV 202	**Science of Environment and Climate**	4
		2 courses (Maths, Physics, Chemistry, Computer Science, Statistics, Economics, Biology)	4+4
		Open elective (Science)	3
		Open elective (Social Science)	3
			18

Semester V

S. No.	Course Code	Subject	Credit
1	ENV301	**Environmental Problems**	3
2	ENV302	**Environmental Field Methods**	3
		2 Courses from Biology	3+3
		Open elective (Science)	3
		Open elective (Other than Science)	3
			18

Semester VI

S. No.	Course Code	Subject	Credit
1	ENV303	**Current Trends in Environmental Science**	3
2	ENV304	**Project**	3
		2 Courses from Biology	3+3
		Open elective (Science)	3
		Open elective (Other than Science)	3
			18

B. M.Sc. ENVIRONMENTAL SCIENCE (2 YEARS)

Program Objectives

1. Impart basic knowledge about the environment and its allied problems at local, regional and global scale.
2. Train the students for scientific analyses of environmental components and its management.
3. Provide practical training on modern instrumentation and analytical techniques for environmental analyses.
4. Prepare for global competence for career options in research fellowship programmes, education, research, industries, consultancy, environmental journalism, etc.
5. Understanding the impacts of climate change, environmental pollution and mitigation strategies.

Program Outcomes

After completion of Programme, student will able to

1. Use concepts and methods from ecological, biological, chemical, geological and geospatial sciences and their application in environmental problem-solving.
2. Apply environmental concepts and methodologies to analyse and understand the interactions between social and environmental processes.
3. Demonstrate proficiency in conducting interdisciplinary research and communication skills.
4. Demonstrate an understanding of legal, regulatory and ethical considerations relating to environment.
5. Availability of qualified personnel for advance research.

Central University of Rajasthan
School of Earth Sciences
M.Sc. Environmental Science (2 year)
Course Structure

Semester I/VII

S. No.	Subject Code	Name of the Subject	Credit
1	ENV401	Ecology and Environment	4
2	ENV402	Environmental Chemistry	4
3	ENV403	Environmental Geoscience	4
4	ENV404	Environmental Pollution	4
5	ENV405	Environmental Laboratory-I	2
6	ENV4XX	D-Elective (Discipline)	4
7		Fitness	0.5
8		Societal	0.5
		Total Credits	**23**

Semester II

S. No.	Subject Code	Name of the Subject	Credit
1	ENV406	Instrumentation for Environmental Monitoring and Analysis	4
2	ENV407	Air and Water Quality Management	4
3	ENV408	Remote Sensing and GIS	4(T+L*)
4	ENV409	Environmental Laboratory-II	2
5	ENV4XX	D-Elective (Discipline)	4
6	ENV4XX	D-Elective (Discipline)	4
7	ENV4XX	Elective (Ex-Discipline)	4
8		Fitness	0.5
9		Societal	0.5
		Total Credits	**27**

Semester III/IX

S. No.	Subject Code	Name of the Subject	Credit
1	ENV501	Arid Environment and Desert Meteorology	4
2	ENV502	Environmental Biotechnology	4
3	ENV503	Environmental Toxicology	4
4	ENV504	Environmental Laboratory-III	2
5	ENV505	Internship/Skill enhancement	2
6	ENV5XX	D-Elective (Discipline)	4
7	ENV5XX	Ex-Elective (Ex-Discipline)	4
8		Fitness	0.5
9		Societal	0.5
		Total Credits	**25**

Semester IV

S. No.	Subject Code	Name of the Subject	Credit
1	ENV506	Dissertation	16
2	ENV5XX	Elective-Open	4
3		Fitness	0.5
4		Societal	0.5
		Total Credits	**21**

Total: 96 Credits

Note:

1. Minimum 6 students are required to run elective courses (List enclosed)
2. Open electives can be selected from any department of the university.
3. MOOCs can be selected based on the availability

*T- Theory; L-laboratory

Elective Courses I *

S. No.	Subject Code	Name of the Subject	Credit
1	ENV410	Soil Science	4
2	ENV411	Agrometeorology	4
3	ENV412	Wastewater Treatment	4(2T+2P)
4	ENV413	Environmental Disasters and Management	4
5	ENV414	Solid Waste Management	4
6	ENV415	Natural Resources, Biodiversity and Wildlife Conservation	4
7	ENV416	Coastal and Marine Environment	4
8	ENV417	Environmental Legislation	4
9	ENV418	Energy and Environment	4
10	ENV419	Environmental Impact Assessment and Management	4
11	ENV420	Global Climate Change Science	4
12	ENV421	Forest Ecology and Management	4
13	ENV422	Sustainable Agriculture and Environmental Practices	4
14	ENV423	Environmental Statistics and Computer Programming	4
		Massive Open Online Courses (MOOCs)	4

Elective Courses II**

S. No.	Subject Code	Name of the Subject	Credit
1	ENV507	Geoinformatics for Forest Management	4
2	ENV508	Occupational Hazards	4
4	ENV509	Water Resource Management	4
5	ENV510	Aquatic and Chemical Ecology	4
6	ENV511	Glaciology and Climate Change	4
7	ENV512	Environmental Stress on Vegetation	4
8	ENV513	Carbon Capture and Sequestration Technology	4
		Massive Open Online Courses (MOOCs)	

These courses will be opened for students of VIIth and VIIIth semester
***** These courses will be opened for students of IXth and Xth semester***

C. Ph.D. ENVIRONMENTAL SCIENCE

Program Objectives

1. To create a researcher focused on interdisciplinary socio-ecological issues and application of sustainable approaches for addressing environmental concerns and challenges
2. To train and provide hands-on training to students in modern tools and techniques to address environmental issues
3. To prepare future manpower for designing, conducting independent research in the area of their interest.

Program Outcomes

After successful completion of the program, the student will be

1. Able to work on various interdisciplinary aspects of the environment for sustainable development of society
2. Able to handle recent tools and techniques to find the solution for various environmental challenges
3. Able to work as an independent researcher to work for society and contribute to solutions to the environmental challenges

Central University of Rajasthan
School of Earth Sciences
Ph.D. Environmental Science
Course Structure

No	Course Code	Title of the course	Type of Course	Credits
1	ENV701	Research Methodology	Core	4
2	ENV702	Research Ethics	Core	3
3	ENV703	Research Review Writing and Seminar	Elective	3
4	ENV704	Advance Analytical Techniques	Elective	3
3	ENV705	Water Resources and Climate Change	Elective	3
4	ENV706	Air Pollution, Monitoring, Control and Effects	Elective	3
5	ENV707	Environmental Microbiology & Biotechnology	Elective	3
6	ENV708	Nanotechnology: Environmental Applications	Elective	3
7	ENV709	Geospatial Technology for Environmental Management	Elective	3
8	ENV710	Biogeochemistry	Elective	3
9	ENV711	Advances in Glaciology	Elective	3

Total Credit Requirement: 16 (7 credits core courses + 9 credits elective course)
Compulsory Course (8 credits): ENV701 (4 credits), ENV702 (3 credits)
Elective Course (3 credits): the student has to select any three courses from the list of elective courses as per his/her requirement

M.Sc. Integrated Environmental Science
(5 years)

Central University of Rajasthan
School of Earth Sciences
Department of Environmental Science
Integrated M.Sc. Environmental Science (5 years)
SYLLABUS

Semester III

ENV 201: Environmental Studies (3 Credits)

School: School of Earth Sciences	**Batch: 2020-2021**	
Program: Environmental Science Integrated M.Sc. (5 years)	**Current Academic Year: 2020-2021**	
	SEMESTER III	
1	Course No	**ENV 201**
2	Course Title	**Environmental Studies**
3	Credits	**3**
4	Course Status	**Core**
5	Course Objective	1. To be acquainted with the concepts, principles, and importance of environmental science and natural resources 2. To know the ecosystem and its conservation 3. To be acquainted with the biodiversity and its conservation. 4. To know the environmental pollutions and its effects as well as a control mechanism 5. Social issues and associated impact on the environment
6	Course Outcomes **(CO)**	**CO1.** Knowledge and importance of various types of natural resources **CO2.** Knowledge of Ecosystems and its importance **CO3.** Understanding of values, threats and conservation of biodiversity **CO4.**Understanding of effects and control measures of different kinds of pollution **CO5.** Understanding of social issues and environmental concerns

7.0	**A**	**General Introduction and Natural Resources**		
7.01	A1	Unit A Topic 1	Multidisciplinary nature of environmental studies, Definition, principles and scope of environmental science, Global nature of environmental problems	CO-1
7.02	A2	Unit A Topic 2	Forest Resources	CO-1
7.03	A3	Unit A Topic 3	Water Resources	CO-1
7.04	A4	Unit A Topic 4	Mineral Resources	CO-1

7.05	A5	Unit A Topic 5	Food Resources	CO-1
7.06	A6	Unit A Topic 6	Energy Resources	CO-1
7.07	A7	Unit A Topic 7	Land Resources	CO-1
7.08	**B**	**Ecosystems**		
7.09	B1	Unit B Topic 1	Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem	CO-2
7.10	B2	Unit B Topic 2	Ecological succession, Food chains, food webs and ecological pyramids.	CO-2
7.11	B3	Unit B Topic 3	Structure and function of the following ecosystem: a) Forest ecosystem, b) Grassland ecosystem, c) Desert ecosystem, d) Aquatic ecosystems	CO-2
7.12	**C**	**Biodiversity and its Conservation**		
7.13	C1	Unit C Topic 1	Introduction: Genetic, Species and Ecosystem Diversity, Biogeographical classification of India	CO-3
7.14	C2	Unit C Topic 2	Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values	CO-3
7.15	C3	Unit C Topic 3	Biodiversity at global, national and local levels, Hot spot of biodiversity, Conservation of biodiversity	CO-3
7.16	**D**	**Environmental Pollution (Cause, effects, control measures and Legislations)**		
7.17	D1	Unit D Topic 1	Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution,	CO-4
7.18	D2	Unit D Topic 2	Solid waste Management: Causes, effects and control measures of urban and industrial wastes	CO-4
7.19	D3	Unit D Topic 3	In brief about the Acts: Air (Prevention and Control of Pollution) Act., Water (Prevention and Control of Pollution) Act, Wildlife Protection Act and Forest Conservation Act	CO-4
7.20	**E**	**Social Issues and the Environment**		
7.21	E1	Unit E Topic 1	Sustainable development, Environmental Impact Assessment (EIA), Water conservation, rainwater harvesting, watershed management	CO-5
7.22	E2	Unit E Topic 2	Resettlement and rehabilitation of people; its problems and concerns. Case studies	CO-5

7.23	E3	Unit E Topic 3	Climate change, global warming, acid rain, ozone layer depletion	CO-5
7.24	E4	Unit E Topic 4	Population growth, variation among nations, Population explosion and its consequences	CO-5
8.0	**Course Evaluation**			
8.1	End Semester Examination		60 Marks	
8.2	Internal Assessment Test-1		20 Marks	
8.3	Internal Assessment Test-2		20 Marks	
8.4	Assignment			
8.5	Projects		none	
8.6	Presentation		one	
9.1	Text book	1. *Joseph, Benny, "Environmental Studies", Tata Mcgraw-Hill.* 2. *S.C. Santra, "Environmental Science", 2nd Edition, New Central Book Agency (P) Ltd, Kolkata, India, 2005.* 3. *Miller, G.T., "Introduction to Environmental Science", Cengage Learning.* 4. *A Text Book of Environmental Studies, D. K. Asthana and Meera Asthana, S. Chand & Co., New Delhi.* 5. *Rao, P.V., "Principles of Environmental Science and Engineering", Prentice Hall of India*		

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4
CO1	**3**	**1**	**1**	**2**
CO2	**3**	**1**	**2**	
CO3	**3**	**2**	**2**	**2**
CO4	**2**	**3**	**1**	**3**
CO5		**2**	**3**	**3**
Level: 1-Low; 2-Medium; 3-High				

Semester IV

ENV 202: Science of Environment and Climate (4 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Environmental Science Integrated M.Sc. (5 years)		**Current Academic Year: 2020-2021** **SEMESTER IV**
1	Course Code	**ENV202**
2	Course Title	**Science of Environment and Climate**
3	Credits	**4**
4	Course Status	**Core**
5	Course Objective	1. To give an understanding of basic processes and principles for environmental and global climatic systems. 2. 2. Understanding climatic and environmental changes and create the background to the linkage between science, society and governance.
6	Course Outcomes	**CO1.** Describe the linkage between different components of the Earth system and climatic development of the Earth. **CO2.** Explain the basic principles and laws global climate system. **CO3.** Understanding climate change causes and human interactions. **CO4.** Account for the impact of climate change on society and the role of various mitigation and adaptative measures.
7	Course Description	To develop a basic understanding of environmental processes and the global climate system.
8	Outline syllabus	CO Mapping
9	**UNIT I** **Introduction**	**CO1/CO4**
	Earth System and components; Introduction to the atmosphere; Structure of atmosphere; Atmospheric thermodynamics; Dynamics of atmospheric processes; Earth's energy balance; Energy transfers in the atmosphere.	
	UNIT II **Earth and Global Climate System**	**CO2/CO4**
	Evolution and development of Earth's atmosphere; Biogeochemical cycles; hydrological cycle; Meteorological phenomenon and basics atmospheric chemistry; atmospheric radiation; Basics of oceanography; Earth's energy balance; Energy transfers in the atmosphere; Earth's radiation budget.	
	UNIT III **Climatic Changes and Impacts**	**CO3/CO4**
	Greenhouse gases and the greenhouse effect; Aerosol effect; Impact of climate change on atmosphere; Human interaction with the earth system; Land-use dynamics; Climate change causes and impacts.	

	UNIT IV **Global Environmental Issues and Mitigation**			**CO4/CO4**
	An integrated approach of climate change; Adaptation and mitigation; Sustainability and environmental issue management; International initiatives to control global climate changes; Convention and treaties related to environmental issues.			
10	Mode of examination	Theory		
11	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
12	Suggested readings			

1. *Lewis A. Owen. Introduction to Global Environmental Issues, Routledge. 1997.*
2. *David D. Kemp. Global Environmental Issues: A Climatological Perspective, Routledge. 1994.*
3. *John M. Wallace, Peter V. Hobbs. Atmospheric Science: An Introductory Survey, Elsevier, 2006*
4. *Peter V. Hobbs, Peter Victor Hobbs. Introduction to Atmospheric Chemistry, 2000*
5. *A. Chandrasekar, Basics of Atmospheric Science, PHI Learning Pvt. Ltd., New Delhi, 2010*
6. *Mark Maslin. Climate Change Very Short Introduction, Oxford, 2014*

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**
CO1	**3**			**1**
CO2	**3**	**2**	**1**	**2**
CO3	**2**	**3**		
CO4		**3**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High				

Semester V

ENV301: Environmental Problems (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**	
Program: Environmental Science Integrated M.Sc. (5 years)		**Current Academic Year: 2020-2021** **SEMESTER V**	
1	Course Code	**ENV301**	
2	Course Title	**Environmental Problems**	
3	Credits	**3**	
4	Course Status	**Core**	
5	Course Objective	1. To impart knowledge to students on pollution in different environmental compartments and climate change 2. To study the role of key stakeholders in local, regional and global environmental issues. 3. To articulate interdisciplinary, historical, ethical, global and cross-cultural links of environmental issues between human and natural systems.	
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to learn **CO1.** The students should be able to learn about various environmental issues including pollution, climate change, and the Ozone hole, etc. **CO2.** The students should be able to understand the effect of spatial (local, regional and global), temporal (days, years, centuries) and intensity (relative to other issues) of environmental problems and mitigation measures **CO3.** The students should be able to attain the understanding on the origin of different environmental pollutants and their indirect and direct effect on human and plant health.	
7	Course Description	This course will encompass an overview of major environmental issues of the world. This course will cover Air, Water and Soil pollution problems in addition to global warming -from the origin of pollutants to consequent impact on environment and health. It will also cover the popular pollution mitigation technologies and sensitization on global warming and climate change issues.	
8	Outline syllabus		CO Mapping
	UNIT I **Air pollution:**		**CO1, CO3/CO3**
	Sources, classification – criteria and specific pollutants, effects of air pollution on plants, human health, material and ecosystem, sampling and analysis of air pollutants – SOx, NOx, ozone, suspended particulate matter (SPM) - coarse and fine, air quality and emission standards. General methods of control of air pollutants, Problems associated with automobile pollution and control methods.		

	UNIT II **Water pollution**			**CO1, CO3/CO3**
	Sources, species and water quality, eutrophication, bioaccumulation, biomagnification, bioindicators, sampling and analysis, CPCB discharge standards, fluoride distribution in groundwater, defluoridation technique, industrial effluents, Effluent Treatment Plants, sewage Treatment Plants, Restoration of water bodies.			
	UNIT III **Soil Pollution and Bioremediation**			**CO1, CO3/CO3**
	Sources of soil pollution – fertilizers, pesticides, detrimental effects of soil pollutants on flora, fauna, contaminants in soil, water and their transfer to the biosphere, Bioremediation technologies- Insitu and ex-situ bioremediation, wastelands and wasteland reclamation			
	UNIT IV **Global Environmental Issues and International Conventions**			**CO1, CO2, CO3/CO3**
	Acid rain and its effects on ecosystems; Chemistry of ozone and Ozone depletion-causes, consequences and remedies, Greenhouse effect, global warming & Climate change- causes and impact, International initiatives to control global warming, Kyoto Protocol, Montreal Protocol, UNFCCC, Hazardous waste and trans-boundary movements, Ramsar convention, UN Summit, Millennium Development Goals, Stockholm Conference on Human Environment Earth Summit, Convention to Combat Desertification.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	Recommended Reading 1. *Baird, C., and Cann, M., Environmental Chemistry, W.H. Freeman and Company, 2008.* 2. *Botkin, Daniel B. and Keller, Edward A. Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA. 2007.* 3. *Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science. Enquiry and Applications. 2nd ed. Tata McGraw Hill, New Delhi. 2004.* 4. *De, A.K., Environmental Chemistry, New Age International (P) Ltd. Publishers, New Delhi, 2000.* 5. *Manahan, S. Environmental chemistry. CRC press, 2017.* 6. *Manahan, Stanley E. Fundamentals of environmental chemistry. CRC press, 2011.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**
CO1	**3**	**2**	**2**	
CO2	**2**	**2**	**1**	**3**
CO3	**3**		**3**	**2**
Level: 1-Low; 2-Medium; 3-High				

ENV302: Environmental Field Methods (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Environmental Science Integrated M.Sc. (5 years)		**Current Academic Year: 2020-2021** **SEMESTER V**
1	Course Code	**ENV302**
2	Course Title	**Environmental Field Methods**
3	Credits	**3**
4	Course Status	**Core**
5	Course Objective	1. To introduce basic tools and techniques required for collection and sampling of water and soil samples. 2. To make student understand how the basic experiments related to water and soil parameters are performed. 3. To expose students to standard methods used in air monitoring, noise measurement and biodiversity studies.
6	Course Outcomes	By the end of the course the student should be able to **CO1.** Identify environmental features in the field. **CO2.** Carry out simple environmental measurements and record them on graphs and tables. **CO3.** Develop basic analytical skills for analysis of environmental samples and interpret experimental findings.
7	Course Description	This course introduces students to work in the field, where data are collected, and observations are made as well as enhances their analytical skills in the laboratory.
8	Outline syllabus	CO Mapping
	UNIT I **Sampling**	**CO1/CO3**
	Introduction to sample collection; Sampling devices; Sample containers; Sampling methods; Preservation methods; Health and Safety precautions.	
	UNIT II **Water Quality and Soil Quality**	**CO2, CO3**
	Water sampling; Determination of water quality basic parameters – pH, Electrical Conductivity, Total Dissolved Solids, Acidity and Alkalinity of water samples. Soil Sampling; Determination of water quality basic parameters – pH, Electrical conductivity, Acidity and alkalinity of soil samples.	
	UNIT III **Air Quality**	**CO2, CO3**
	Visit to Ambient Air Quality Monitoring station, (SOx , NOx, O_3, HC, SPM, RSPM); Measurement of noise pollution.	
	UNIT IV **Ecology**	**CO2, CO3**

	Study plant population frequency, density and abundance by quadrat method			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Handbook of methods in Environmental Studies Vol—I & II; S.K. Maiti; ABD Publishers, Jaipur, India* 2. *G. Swarajya Lakshmi, Prabhu Prasadini P, Ramesh Thatikunta, Tayaru V.N.L.V. Environmental Science : A Practical Manual;, BS Publications/BSP Books, 2010.* 3. *Radojevic M. and Valdimir N.B. Practical Environmental Analysis, RSC publishing, 2006.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**
CO1	**3**	**3**	**2**	**2**
CO2	**2**	**3**		**3**
CO3	**2**	**3**	**1**	**3**
Level: 1-Low; 2-Medium; 3-High				

Semester VI

ENV303: Current Trends in Environmental Science (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Environmental Science Integrated M.Sc. (5 years)		**Current Academic Year: 2020-2021** **SEMESTER VI**
1	Course Code	**ENV303**
2	Course Title	**Current Trends in Environmental Science**
3	Credits	**3**
4	Course Status	**Core**
5	Course Objective	1. To explain the current challenges and trends in the field of environment 2. To develop scientific knowledge on various processes to manage and control pollution
6	Course Outcomes	By the end of the course, the student should be able to learn **CO1.** Describe the key environmental challenges and their analysis **CO2.** Gain scientific perspective of the issues confronting our present-day environment **CO3.** Examine the critical linkage between environmental pollution and human health **CO4.** Increase awareness and other management skills to protect the environment
7	Course Description	To understand trends in Environmental Science
8	Outline syllabus	CO Mapping
	UNIT I **Environmental Pollution**	**CO1/CO4**
	Definition and sources of pollution; Different types of pollution and their global, regional and local aspects. Definition and sources, Chemical and biological effects of thermal pollution, Sources and types and constituents of E-wastes and its environmental consequences.	
	UNIT II **Energy Resources**	**CO2/CO4**
	Concept and demand for energy, Growing energy needs, renewable and nonrenewable sources, use of alternate energy sources, clean energy, environmental health and safety	
	UNIT III **Environmental Policies**	**CO3/CO4**
	Sustainable Development Goals, Agenda 21, Fundamental principles of environmental protection - sustainable development- Brundtland report 1987. Environmental Regulatory Framework in India. Role of International Environmental Agencies -UNEP, GEF, UNFCC and IPCC	

	UNIT IV **Green Technology**			**CO4/CO4**
	Biocatalysis, green chemistry in industries, fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources; Solar photovoltaic technology, Biofuel production (bio-ethanol and biodiesel), Production of biodegradable materials, the concept of green building, Pollution free engineering processes.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. M. H. Fulekar (2010) Nanotechnology Importance and applications, I K international publishing house Pvt. Ltd. *2. Lynn Goldman, Christine Coussens, Implications of nanotechnology for environmental health research, National Academic Press, Washington, 2007* *3. Matlack, A. S. Introduction to Green Chemistry. Marcel Dekker: New York, 2001*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**
CO1	**3**	**3**	**2**	
CO2	**3**	**1**	**2**	
CO3	**2**		**3**	**2**
CO4			**3**	**2**
Level: 1-Low; 2-Medium; 3-High				

ENV304: Project **(3 Credits)**

School: School of Earth Sciences		**Batch: 2020-21**		
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER VI**		
1	Course Code	**ENV304**		
2	Course Title	**Project**		
3	Credits	**3**		
4	Course Status	**Core**		
5	Course Objective	1. Understanding of environmental laboratory practices. 2. To identify environmental problems existing in the area of interest and generate research questions. 3. Environmental sampling, evaluation, analysis and interpretation of data.		
6	Course Outcomes	By the end of the course, the student should be able to **CO1.** Learn and execute environmental laboratory practices. **CO2.** Understanding of environmental research problems.		
7	Course Description	Designed for enhancing laboratory practices and skills in Environmental Science for any research problems.		
8	Outline syllabus			
	Each student will work for Project under the supervision of assigned supervisor in the department. Student shall complete the process of academic interaction to obtain teachers consent to supervise his/her project work. The work on research project will start under the supervision of assigned faculty member and will be completed by end of 6th semester with submission of project report. Project will be evaluated by the committee based on their research report and viva-voce.			
9	Mode of examination	Report + Presentation		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**
CO1		**3**		**3**
CO2	**2**	**1**	**2**	**2**
Level: 1-Low; 2-Medium; 3-High				

M.Sc. Environmental Science
(2 years)

Central University of Rajasthan
School of Earth Sciences
Department of Environmental Science
M.Sc. Environmental Science (2 years)
SYLLABUS

Semester I

ENV401: Ecology and Environment **(4 Credits)**

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I**
1	Course Code	**ENV401**
2	Course Title	**Ecology and Environment**
3	Credits	**4**
4	Course Status	**Core**
5	Course Objective	1. To impart knowledge on the different environmental and ecological setup of various ecosystems. 2. To understand the community dynamics in terms of energy and food relationships. 3. To understand the interactions of organisms and their environments and the consequences of these interactions for population, community, and ecosystem dynamics.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to learn: **CO1.** This will lead to central ideas behind the ecology of individuals, populations, communities and/or ecosystems; **CO2.** This will lead to the development of critical thinking about scientific evidence to understand ecological patterns and processes and different ecological phenomenon **CO3.** Apply this basic knowledge in ecological assessment and research.
7	Course Description	To develop a basic understanding of Ecology and Environment
8	Outline syllabus	CO Mapping
	UNIT-I **Ecological concepts & Interaction of factors:**	**CO1, CO2, CO3/CO3**
	Definition, principles, and scope of Ecology and environment. Physico-chemical (Light, Temperature, pH, Salinity, Physiography, Fire, Nutrients, and biological factors in the environment and their effects on the living world. Interaction of factors and components of the environment, Laws of limiting factors- Liebig's law of tolerance,	

	Shelford's law of tolerance. Habitat sustainability models. Negative and Positive interaction between species.			
	UNIT-II **Population & Community Ecology:**			**CO1, CO2, CO3 /CO3**
	Species and Populations- Population characteristics, Population dynamics in space and time. Human population, demographic transition, carrying capacity of earth. Temporal and spatial variation in abundance. Metapopulation, niches concept, r and K selection, C-S-R Model, Genecology and range extensions. Community organization-concept of habitat, analytical characters, synthetic characters, functional role and niche, key stone species, dominant species, invasive species, ecotone, edge effect. Species diversity and measurement of diversity. Community dynamics- Models of succession, Patch dynamics, Gap dynamics in forest community			
	UNIT-III **Ecosystem structure and dynamics**			**CO1, CO2, CO3/CO3**
	The ecosystem concept, abiotic and biotic components. Solar energy input in an ecosystem, Ecosystem metabolism, Primary and secondary production, Measuring primary production, Efficiency of secondary production co-existence, Concept of food chain & food web, Energy Flow models in an ecosystem. The pattern of production/ productivities in the major ecosystem of the world. Biogeochemical cycles-. Man's impact on nutrient cycles			
	UNIT-IV **Integrated Principles and Ecosystem Diversity:**			**CO1, CO2, CO3/CO3**
	Ecosystem stability and homeostasis, McArthur Hypothesis of ecosystem stability, stability indices, biogeochemical regulation, Development of an ecosystem- Changes in ecosystem characteristics from simple to complex ecosystem, Models of development. Introduction to functional genomics and metagenomics for studying ecosystems. Characteristics of terrestrial and aquatic ecosystems- Biomes and Microbiomes.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
12	Suggested readings			
	▪ *Begon, M., Townsend, C. R., and Harper, J. L. Ecology from Individuals to Ecosystems. Wiley-Blackwell, USA. 2005.* ▪ *Botkin, Daniel B. and Keller, Edward A. Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA. 2007.* ▪ *Chapman, J. L. and Reiss, M. J. Ecology: Principles and Applications. Cambridge University Press, UK. 1998.* ▪ *Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science. Enquiry and Applications.2nd ed. Tata McGraw Hill, New Delhi. 2004.* ▪ *Krebs C. J. The Ecological World View. CSIRO Publishing. Callingwood, Australia, 2008.* ▪ *Odum, E. P. Fundamentals of Ecology, W. B. Saunders, USA.Indian Reprint 1996 by Natraj Publishers, Dehradun. 1991.* ▪ *Odum, E.P. Ecology: A Bridge between Science and Society. Sinauer Associates, Inc., USA. 1997.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**	**1**	
CO2	**2**	**2**	**3**		
CO3			**3**		**3**
Level: 1-Low; 2-Medium; 3-High					

ENV402: Environmental Chemistry (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I**
1	Course Code	**ENV402**
2	Course Title	**Environmental Chemistry**
3	Credits	**4**
4	Course Status	**Core**
5	Course Objective	1. Understand the role of chemistry in environmental science. 2. Gain a clear concept of different chemical phenomena occurring in various environmental matrices i.e. air, water, and soil. 3. Explain the theoretical basis and observational methods for the study of chemical species present in the environment and their interactions with each other.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to: **CO1.** Understand the interconnections between different environmental matrices and the effect of human activities on the natural chemical processes. **CO2.** Apply fundamental concepts of chemistry to analyse chemical processes underlying the operation of the natural environment. **CO3.** Explain how chemical theories are applied to understand global processes and environmental issues. **CO4.** Gain familiarity with processes affecting the sources and fate of environmental contaminants.
7	Course Description	This course covers the chemistry of Earth's environment, including the natural chemical processes as well as anthropogenic contributions. It includes natural processes and pollution problems related to air, water, and soil. In this course, the emphasis is on how the specific discipline of chemistry can help us understand contemporary environmental issues and possible solutions to environmental problems.
8	Outline syllabus	CO Mapping
	UNIT-I **Introduction**	**CO1/CO4**
	Environmental segments & their chemistry – Atmosphere, Hydrosphere, Lithosphere, Biosphere, Anthrosphere; Toxic chemicals in the environment; Green chemistry.	
	UNIT-II **Atmospheric Chemistry**	**CO2/CO3/CO4**
	Structure and composition of the atmosphere; Tropospheric chemistry - Photochemical and oxidation reactions, Hydrocarbons, Oxides of sulphur and nitrogen, Smog, Surface ozone, Halogens, Aerosols; Acid rain; Global warming and greenhouse effect; Stratospheric chemistry - Ozone formation and destruction; Polar stratospheric clouds.	

	UNIT-III **Water Chemistry**			**CO2/CO3/CO4**
	Unique properties of water; Hydrological cycle; Water quality parameters; Characteristics of water bodies; Major aquatic chemical reactions - Carbonate system, Alkalinity and acidity, Metal ions in water, Oxidation-reduction reactions, Complexation, and chelation; Dissolved gases; Water interaction with other phases; Aquatic life and biochemical processes.			
	UNIT-IV **Soil Chemistry**			**CO2/CO3/CO4**
	Soil formation; soil classification; Soil properties; Soil minerals; Soil organic matter; Soil pH and buffer capacity; Soil acidity and alkalinity; Soil colloids; Ion-exchange processes in the soil; Soil water; Soil aeration; Soil Nutrients.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Manahan, S. E. Fundamentals of Environmental Chemistry. 2nd ed. CRC Press, Inc., US. 2001.* 2. *Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company. 2008.* 3. *De, A. K. Environmental Chemistry. 4th ed. New Age International (P) Ltd., New Delhi, India.2001.* 4. *Harrison, R. M. and de Mora, S. J. Introductory Chemistry for the Environment Science. 2nd ed. Cambridge University Press, New Delhi. 1996.* 5. *Sawyer, C.N. and McCarty, P.L. G.F. Parkin (eds). Chemistry for Environmental Science and Engineering,Tata-McGraw-Hill Edition. 2003.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**2**		**1**	
CO2	**3**	**2**	**2**		
CO3	**2**	**3**		**1**	**2**
CO4	**2**	**3**	**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

ENV403: Environmental Geosciences (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**			
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21**			
		SEMESTER I			
1	Course Code	**ENV 403**			
2	Course Title	**Environmental Geosciences**			
3	Credits	**4**			
4	Course Status	**Core**			
5	Course Objective	1. To introduce students to the basic concepts and principles of physical and environmental geology, focusing on Earth materials and processes. 2. To provide students with an understanding of questions like how geologic processes and hazards influence human activities (and sometimes the reverse), the geologic aspects of pollution and waste-disposal problems, and several other environmental processes.			
6	Course Outcomes **(CO)**	**CO1.** The students would be able to understand the spectrum of interactions between people and the physical environment. **CO2.** The students would develop an understanding of how geology interacts with major environmental problems facing people and society. **CO3.** The knowledge shared with the students will provide a useful foundation for discussing and evaluating specific environmental issues, as well as for developing ideas about how the problems should be solved.			
7	Course Description	To provide a framework for learning about the immense forces at work at Earth's surface and in its interior.			
8	Outline syllabus				CO Mapping
	UNIT-I **Introduction**				**CO1**
	The earth system, plate tectonics, minerals and rocks, igneous rocks, sedimentary rocks, metamorphism				
	UNIT-II **Geologic processes**				**CO1/CO2**
	Geological time scale, igneous, sedimentary and metamorphic processes; deformations				
	UNIT-III **Internal and surficial geosystems**				**CO2/CO3**
	Volcanoes, earthquakes, weathering, erosion, and mass wasting; stream transport, winds and deserts				
	UNIT-IV **Geochemical cycles**				**CO3**
	Concept of major, minor and trace elements; mobility of elements, geo-indicators, mineral resources				
	Mode of examination	Theory			
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination	

		20%	20%	60%
	Suggested Readings	*1. Keller, E.A. Introduction to Environmental Geology. 4th ed. Prentice Hall of India. 2007.* *2. Eby, N. Principles of Environmental Geochemistry. Brooks Cole, USA. 2003.* *3. Bennett, M.R. and Doyle, P. Environmental geology: - Geology and the Human Environment. John Wiley and Sons.1997.* *4. Botkin, Daniel B. and Keller, Edward A. Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA. 2007.* *5. Grotzinger J., Jordan Thomas H., Press Frank, Siever Raymond: Understanding Earth; Freeman and Company. 2014.*		

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	**3**	**2**	**1**	
CO2		**3**	**2**		**3**
CO3	**1**		**3**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High					

ENV404: Environmental Pollution (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I**	
1	Course Code	**ENV404**	
2	Course Title	**Environmental Pollution**	
3	Credits	**4**	
4	Course Status	**Core**	
5	Course Objective	1. To study the sources, analysis, and impacts of environmental pollution on a local and regional scale. 2. To gain a clear concept over water and air quality parameters and standards 3. Studying the techniques/methods for the analysis of various processes based on Physico-chemical. 4. Explain the pollution control methods and management strategies	
6	Course Outcomes **(CO)**	**CO1.** Understanding of the essential concepts of environmental pollution, classification, and its sources. **CO2.** To gain clear concepts over air and water pollution and its impacts. **CO3.** Concept of noise, radioactive, and thermal pollution causes and effects. **CO4.** Understanding standards of the pollution level and its management as well as the impact on human health.	
7	Course Description	Understanding of environmental pollution, their sources, effects, analysis, and mitigation measures.	
8	Outline syllabus		CO Mapping
	UNIT-I **Pollution - Sources, Causes, and Effects**		**CO1/CO4**
	Definition of pollution; pollutants; Classification of pollutants; Major sources of environmental pollutants; Local, regional and global aspects of environmental pollution, transportation of pollutants, Concept of biotransformation and bioaccumulation and their effects on the environment.		
	UNIT-II **Air and Water Pollution**		**CO2/CO4**
	Air pollution- sources and effects of SO_x, NO_2, O_3, HF, photochemical smog and particulates on plants and human health; air Quality parameters; Mitigation of air pollution; Mechanical and engineering methods. Indoor air pollution: sources and effects. Water pollution- types and sources, effects on water quality, water quality parameters and standards; Drinking water treatment, water disinfection; wastewater treatment.		
	UNIT-III **Soil, Noise, and Thermal Pollution**		**CO3/CO4**

	Soil pollution causes and effects; Soil reclamation methods; Noise pollution, Radioactive pollution; Thermal pollution-sources, effects and abatement methods.			
	UNIT IV	**Pollution Standards, Control, and Impact on Human health**		**CO4**
	Pollution control management and regulatory standards and framework for control policies; Ambient air and water quality and their quality index; Effects of different pollutants on human health and control measures.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Environmental and Pollution Science (2nd Edition) by Ian Pepper Charles Gerba Mark Brusseau, eBook ISBN: 9780080494791, Academic Press* 2. *Understanding Environmental Pollution 3rd Edition by Marquita K. Hill, Cambridge University Press SBN-13: 978-0521736695* 3. *Environmental Pollution and Control, 4th Edition by Jeffrey Peirce P Aarne Vesilind Ruth Weiner, ISBN: 9780750698993* 4. *Environmental Pollution Control Engineering, by C.S. Rao, Publisher: New Age International Publishers; Third edition ISBN-10: 9386649896* 5. *Environmental Chemistry by A.K. De, New Age Publications India Ltd., ISBN: 9788122426175*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**			
CO2		**3**	**3**	**2**	
CO3		**3**		**1**	**2**
CO4	**3**		**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High					

ENV405: Environmental Laboratory-I (2 Credits)

School: **School of Earth Sciences**		**Batch: 2020-21**
Program: **M.Sc. Environmental Science**		**Current Academic Year: 2020-21** **SEMESTER-I**
1	Course Code	**ENV405**
2	Course Title	**Environmental Laboratory-I**
3	Credits	**2**
4	Course Status	**Core**
5	Course Objective	1. Provide a basic foundation of knowledge on the implication of environmental monitoring and ecology in the laboratory 2. Giving hands-on experience to conduct the laboratory practical with precision 3. Understanding the practical aspect of ecology, and analysis of soil, water, and air samples 4. To develop an understanding of geological samples through field visits and analysing samples.
6	Course Outcomes **(CO)**	**CO1.** Students will be ready to opt for environmental and ecological analysis parts of laboratories in higher studies, professional bodies and research institutes. **CO2.** Students will understand the appropriate methods and principle behind the practical protocols **CO3.** Students will understand how to analyse the soil, air and water samples. **CO4.** Students will understand the identification of the geological samples in the field during routine field visits; understanding of physical factors shaping the geomorphic features.
7	Course Description	The course is designed to provide significant aid and exposure to the students for the statistics and basic computer programming required for the environmental analysis of the variables/data in addition to present and validate the hypothesis.
8	Outline syllabus	CO Mapping
	UNIT 1 **Ecology**	**CO1/CO4**
	Determination of abundance, dominance and frequency of a grassland ecosystem; Determination of diversity index of aquatic ponds and terrestrial ecosystem; Understanding the community & population structure in addition to succession phenomena in the field; Determination of primary productivity of an ecosystem	
	UNIT II **Environmental Chemistry**	**CO2, CO3/CO4**
	Air analysis: Oxides of Nitrogen, Ozone and Sulphur, SPM and RSPM; Water analysis: pH, Electrical Conductivity, Turbidity, Total Suspended Solids, Total Dissolved Solids, Dissolved Oxygen, Acidity and Alkalinity; Soil analysis: Moisture content, Organic carbon, Organic matter, Water holding capacity.	

	UNIT III Geoscience			**CO4/CO4**
	Particle size analysis; Bulk density; Loss-on ignition; Mineral identification			
9	Mode of examination	Practical		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. Handerson P A, Practical Methods in Ecology. Wiley Publishers *2. Lodge J P, Methods of Air Sampling and Analysis. CRC Press* *3. Page A L, Methods of soil analysis. American Society of Agronomy, Inc. Soil Science Society of America, Inc. Publisher* *4. APHA (1998). Wpcf. Standard methods for the examination of water and wastewater, 20.* *5. Grasshoff et al. Methods of seawater analysis. Third Edition. Wiley VCH publications*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	**2**		**1**	**3**
CO2	**2**	**3**	**3**		
CO3			**3**	**1**	**3**
CO4	**2**		**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

Semester II

ENV406: Instrumentation for Environmental Monitoring and Analysis (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		Current Academic Year: **2020-21**	
		SEMESTER II	
1	Course Code	**ENV406**	
2	Course Title	**Instrumentation for Environmental Monitoring and Analysis**	
3	Credits	**4**	
4	Course Status	**Core**	
5	Course Objective	1. To develop an understanding of the principles of sampling, chemical analysis, and instrumentation which is more important than knowing 'specific how'. 2. To introduce the students with the basic aspects of the environmental chemical data collection process, such as systematic planning, sensible field procedures, solid analytical chemistry, and the evaluation of data quality in the context of their intended use. 3. To expose students to the fundamental instrumental techniques that are part of environmental projects.	
6	Course Outcomes **(CO)**	**CO1.** The students will develop a comprehensive view of project work, step-by-step detailed procedures for common field sampling tasks, and a wealth of practical tips for all project tasks. **CO2.** The students will understand the effective role of obtaining data of scientifically reliable and legally defensible nature by exercising good laboratory practices. **CO3.** The students will understand the basics of various instrumentation techniques that may be employed in the environmental data acquisition and would be able to obtain data of intended quality.	
7	Course Description	To provide a framework for learning about sampling needs, procedures, and techniques along with a detailed understanding of modern laboratory instruments.	
8	Outline syllabus		CO Mapping
	UNIT I **Introduction**		**CO1/CO2**
	Environmental Data Acquisition, Basics of Environmental Sampling and Analysis, Environmental Sampling Design, Environmental Sampling Techniques, Quality Assurance/Quality Control of Environmental Analysis, Fundamentals of Sample Preparation for Environmental Analysis, Good Laboratory Practices.		
	UNIT II **Electrochemical Methods for Environmental Analysis**		**CO2/CO3**
	Principles of Electroanalytical Methods, Potentiometric Applications in Environmental Analysis		
	UNIT III **UV-Visible and Infrared Spectroscopic Methods in Environmental Analysis**		**CO2/CO3**

	Principles of Spectroscopy, UV-Visible Spectroscopy, Infrared Spectroscopy, Practical Aspects of UV-Visible and Infrared Spectrometry; Principles of Atomic Spectroscopy, Instruments for Atomic Spectroscopy, Selection of the Proper Atomic Spectroscopic Techniques				
	UNIT IV	**Chromatographic Methods for Environmental Analysis**			**CO2/CO3**
		Instruments of Chromatographic Methods, Common Detectors for Chromatography, Applications of Chromatographic Methods in Environmental Analysis			
	Mode of examination	Theory			
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination	
		20%	20%	60%	
	Suggested Readings	1. *Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.* 2. *Reeve, R. Introduction to Environmental Analysis. John Willey & Sons.2002.* 3. *Skoog, D. A., Holler, F.J., &Crouch, S.R. (2006) Principles of Instrumental Analysis, Brooks Cole.* 4. *Chatwal, G. R., and Anand, S. K. Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi. 2007.* 5. *De, A.K. Environmental Chemistry, New Age International, New Delhi. 2000.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**2**	**1**	**3**	**1**	**2**
CO2		**2**	**1**	**3**	
CO3	**2**	**2**	**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

ENV407: Air and Water Quality Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		Current Academic Year: **2020-21**	
		SEMESTER II	
1	Course Code	**ENV407**	
2	Course Title	**Air and Water Quality Management**	
3	Credits	**4**	
4	Course Status	**Core**	
5	Course Objective **(CO)**	1. To train the students about the determination of the air and water quality parameters. 2. To understand the environmental objectives for maintaining air and water quality standards. 3. To understand the complete procedure for getting ISO Certification for achieving environment and quality standards.	
6	Course Outcomes	The student should be able to learn the following outcomes. **CO1.** Evaluate various physicochemical and biological parameters of Water and Air quality. **CO2.** Assess the validity and limitations of these quality parameters **CO3.** Learn about various quality control standardizing bodies **CO4.** Know about various treatment technologies	
7	Course Description	To develop a basic understanding of Air and Water Quality	
8	Outline syllabus		CO Mapping
	UNIT I **Air Quality**		**CO1/CO4**
	Sources of air pollutants, Criteria air pollutants, Air quality standards, Monitoring National Ambient Air Quality Standards, Air quality surveillance network, Control approaches (stationary and mobile), Indoor air pollution and its quality management		
	UNIT II **Water Quality**		**CO2/CO4**
	Water quality standards (physical, chemical, microbiological, radiological), Water quality modelling, Emerging pollutants in water, Pollutant fate and transport		
	UNIT III **Quality Management**		**CO3/CO4**
	Air (pollution and control of Prevention) Act, Clean Water (pollution and control of Prevention) Act, Briefs about CPCB, BIS, ISO, USEPA, WHO, ISO 9000, 14000, Hazard Analysis Critical Control Point (HACCP)		
	UNIT IV **Treatment Technologies**		**CO4/CO4**
	Air quality control measures, Water quality assurance, Advanced water treatment techniques, Control of emerging pollutants, Analytical techniques		

9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	4. *Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.* 5. *Reeve, R. Introduction to Environmental Analysis. John Willey & Sons.2002.* 6. *Skoog, D. A., Holler, F.J., &Crouch, S.R. (2006) Principles of Instrumental Analysis, Brooks Cole.* 7. *Chatwal, G. R., and Anand, S. K. Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi. 2007.* 8. *De, A.K. Environmental Chemistry, New Age International, New Delhi. 2000.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**		**3**		**2**
CO2		**3**	**1**	**3**	
CO3		**2**		**3**	
CO4	**2**	**3**			**3**
Level: 1-Low; 2-Medium; 3-High					

ENV408: Remote Sensing and GIS (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		Current Academic Year: **2020-21** **SEMESTER II**
1	Course Code	**ENV408**
2	Course Title	**Remote Sensing and GIS**
3	Credits	**4 (3T+2P)**
4	Course Status	**Core**
5	Course Objective	1. To train the students in identifying, analysing, and solving various problems using geospatial methods. 2. To train the students in practical and executable solutions to the challenges of the emergent field of Remote Sensing and GIS. 3. To impart the students with a strong base of knowledge that makes them suitable both for industries, teaching, and research. 4. To inculcate the students towards public policies and their responsibilities towards society.
6	Course Outcomes **(CO)**	**CO 1.** An ability to individually carry out research/developmental work to solve real-world geospatial problems. **CO 2.** Identify specific data and methodologies for effective mapping and evaluation of natural resources. **CO 3.**Design systems for decision making and work in a team using geospatial tools to achieve project objectives. **CO 4.**An ability to share theoretical and practical knowledge in both teaching and research as well as in industries.
7	Course Description	Impart quality education and equip the students with a strong foundation that could make them capable of handling challenges of the ever-advancing geospatial technologies.
8	Outline syllabus	CO Mapping
	UNIT I **Principles of Remote Sensing**	**CO1/CO4**
	Remote Sensing Concept & Principles, Electromagnetic Radiation (EMR), Atmospheric Windows, Spectral Signatures, Resolutions, Platforms, Satellites, Sensors, and Specifications, Digital Image Processing System, Enhancement, Transformation and Image Classifications, Image Interpretations (Optical, Thermal & Radar)	
	UNIT II **GIS, GPS & GNSS System**	**CO2/CO4**
	Components of GIS, Spatial vs. Non-Spatial Data, Coordinate System, Map Projections, Spatial Data Quarries, Data Formats, Raster & Vector Data Models (Topology, Grid, TIN, Network), Data Input & Geo-Corrections, Spatial Interpolations, Buffering, Overlay Analysis, Terrain Mapping-DEM/DTM. GPS-An Overview, Positioning, System Segmentation, Augmentation, DGPS, & GNSS/IRNSS Applications.	
	UNIT III	**CO3/CO4**

	Geospatial Applications			
	Application of RS & GIS in Monitoring and Management of Natural Resources: Forest, Agriculture, Water, Urban, Ocean, Coastal. Concept of Health GIS, E-Governance & Disaster Management.			
	UNIT IV **Advances in Remote sensing**			**CO4/CO4**
	Thermal and Microwave Remote sensing, Sensor Technology, Platforms and Data Types, Urban Heat Island, Hyperspectral and LASER Remote sensing, Classification and Spectral Library Creation, Applications of RADAR, Hyperspectral & LiDAR, Geospatial Modelling, UAV applications, Basics of web GIS.			
	Mode of Exam	**Theory + Practical**		
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End Semester Examination
		20%	20%	60%
	Suggested readings:			
	1. *Jensen, J.R. (2006). "Remote Sensing of the Environment – An Earth Resources Perspective", Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi.* 2. *Burroughs, Peter A. and Rachael McDonnell (1998). Principles of Geographical Information Systems" Oxford University Press, New York.* 3. *Jensen, J.R. (1996). Introductory Digital Image Processing A remote sensing perspective. Prentice Hall Series in GIS, USA.* 4. *Lillesand, Thomas M. and Kiefer, Ralph, W. (2007). "Remote Sensing and Image Interpretation", 4th Edition, John Wiley and Sons, New York* 5. *Sabin, F.F. Jr. (2007). Remote Sensing – Principles and Interpretation", W.H. Freeman & Co.* 6. *Kang-stung Chang (2007). Introduction to Geographic Information Systems, Tata McGraw Hill, New Delhi.* 7. *Satheesh Gopi (2005). Global Positioning System: Principles and Applications. McGraw Hill Publishers.* 8. *Dale A. Quattrochi et.al. (2004). Thermal Remote Sensing in Land Surface Processing. CRC Press.* 9. *Marcus Borengasser et.al. (2007). Hyperspectral Remote Sensing: Principles and Applications, CRC Press.* 10. *Mitchell, Andy (2012). The ESRI Guide to GIS Analysis, Volume 3: Modeming Suitability, Movement, and Interaction. Redlands, CA, ESRI Press.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1		**2**	**3**		**3**
CO2	**2**	**3**	**2**		**3**
CO3		**3**		**1**	**2**
CO4	**2**	**2**		**2**	**3**
Level: 1-Low; 2-Medium; 3-High					

ENV409: Environmental Laboratory-II (2 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-2021** **SEMESTER II**	
1	Course Code	**ENV409**	
2	Course Title	**Environmental Laboratory-II**	
3	Credits	**2**	
4	Course Status	**Core**	
5	Course Objective	1. To understand the concept of sampling methods, ways to obtain scientifically reliable data and data quality 2. To get hands-on experience with the instruments which are used for environmental sampling and analysis. 3. To perform qualitative and quantitative analysis ofwater and air quality parameters and learn the interpretation of results for problem identification.	
6	Course Outcomes **(CO)**	By the end of the course, the students will be able to **CO1.** Understand the basic principle behind the functioning of any instrument **CO2.** Critically evaluate and interpret experimental data and findings and apply them for problem identification and quantification. **CO3.** Understand the characteristic difference between the types of samples and sampling sites. **CO4.** Understand the role of critical factors responsible in the type of sample	
7	Course Description	For enhancing analytical skills in the laboratory.	
8	Outline syllabus		CO Mapping
	UNIT I **Sampling methods and Data Quality**		**CO1/CO4**
	Practical Tips to Sampling, Sample Preparation, and Metal Analysis; Evaluation of LoB, LoD and PQL.		
	UNIT II **Instrumentation**		**CO2/CO4**
	Use of Ion selective electrodes; Practical aspects of UV-Visible and Infrared Spectrometry, Practical aspects of Chromatographic Methods.		
	UNIT III **Determination of Water-Quality**		**CO3/CO4**
	Analysis of Water Quality parameters – physicochemical, biological parameters, DO, BOD, COD, MPN, Phosphate, Nitrate, fluoride, Heavy metals, etc.)		
	UNIT IV **Determination of Air-Quality**		**CO4/CO4**
	Monitoring of air quality parameters (O_3, SO_x, NO_x, NH_3, SPM, RSPM) etc. outdoor and indoor sampling of air, NAAQMS, principles, workings and applications of High-Volume Dust Sampler, Respirable Dust Sampler		
9	Mode of Examination	Practical	

10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Eaton, A. D., Clesceri, L. S., Greenberg, A. E., & Franson, M. A. H. (2017). Standard methods for the examination of water and wastewater. American public health association, 23, 1504.* 2. *LawrenceH. Keith, Environmental Sampling and Analysis: A Practical Guide 1st Edition, 2017.* 3. *Chaurasia, S., Gupta, A.D.[2014]. Handbook of water, air and soil analysis. International E-publication,123.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**2**			**2**
CO2		**3**	**3**		
CO3	**3**		**3**	**1**	**2**
CO4		**3**	**3**	**2**	
Level: 1-Low; 2-Medium; 3-High					

Semester III

ENV501: Arid Environment and Desert Meteorology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21**	
		SEMESTER III	
1	Course Code	**ENV501**	
2	Course Title	**Arid Environment and Desert Meteorology**	
3	Credits	**4**	
	Course Status	**Core**	
5	Course Objective	1. To learn the process of genesis and dynamics of the desert and its characteristics 2. To learn atmospheric and surface energy budgets in the desert environment. 3. To learn severe weather conditions in the desert environment and the ecological status of the arid area. 4. To learn the effects of deserts on the environment and humans.	
6	Course Outcomes **(CO)**	**CO1.** Understanding of concepts related to the desert and its characteristics. **CO2.** Understanding of the surface energy budget of the desert and its implication on desertification. **CO3.** Understanding of the concept of the severe weather conditions in the desert and ecological status of arid area. **CO4.** understanding of the impact of the deserts on the environment and human	
7	Course Description	To develop an understanding of the arid environment and the desert meteorology and its various technical aspects.	
8	Outline syllabus		CO Mapping
	UNIT I **Dynamics of Arid Environment and Desert**		
	Definition of a desert, General characteristics of desert and desert biomes; Causes of aridity, geomorphology, land use and soil; Dynamic feedback mechanisms- cause and sustaining deserts.The dynamics of desert heat lows.		**CO1/CO4**
	UNIT IIAtmospheric and Surface Energy Budgets of Deserts		
	Basic concepts of atmospheric structure and dynamics; Components of the atmospheric and surface energy budgets; Inter-annual variability in aridity (drought).		**CO2/CO4**
	UNIT III **Severe Weather in the Desert and Arid Ecological Status**		
	Dust storms and sand storms; Monsoon pattern in deserts, Rainstorms, floods, and debris flows; Desert severe weather and desert microclimate; an ecology of arid zone in India.		**CO3/CO4**
	UNIT IV		

	Effects of Deserts on the Environment and Humans				
	Global and regional transport of desert dust; Dynamic effects of deserts on meteorological processes in other regions; Global climate effects of desert dust; Ecological effects of desert dust; Human impact, and desertification; Impact of a desert on human.				**CO4/CO4**
9	Mode of examination	Theory			
10	Weightage Distribution	Internal Assessment -I	Internal Assessment -II	End of Semester Examination	
		20%	20%	60%	
11	Suggested readings				
	Text book/s*	*1. Desert Meteorology by THOMAS T. WARNER, Cambridge university press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo*			
	Other References	*1. Dryland Climatology by Sharon E. Nicholson, Publisher Cambridge University Press* *2. Sharma, Arun K., and J. C. Tewari. "Arid zone forestry with special reference to Indian hot arid zone." Forests and Forests Plants. Eolss Publishers Company, UK (2009): 90-130.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**2**	**1**	**2**
CO2	**2**	**3**			
CO3	**3**	**3**	**2**		**2**
CO4		**3**		**2**	**1**
Level: 1-Low; 2-Medium; 3-High					

ENV502: Environmental Biotechnology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III**
1	Course Code	**ENV502**
2	Course Title	**Environmental Biotechnology**
3	Credits	**4**
4	Course Status	**Core**
5	Course Objective	1. To impart a working knowledge of the principles, techniques, and current applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments and energy production. 2. To understand the principles of bioremediation and phytoremediation of synthetic organic pollutants and the basic physiology of a microorganism during bioremediation studies. 3. Know various techniques to modify and augment microorganisms in the laboratory and environment 4. To train the students about conservation of resources via recycling of waste materials and recovery of valuable products such as metals and oils.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to: **CO1.** Understand the basic principles of microbiology, genetics, and biotechnology **CO2.** Understand the basic microbial processes of environmental engineering systems, natural/advanced environmental biotechnologies. **CO3.** Recognize and apply environmental biotechnology approaches in treatment and disposal of organic wastes **CO4.** Apply this knowledge in production of biomaterials /biofuels and pollution control.
7	Course Description	To develop a basic understanding of Environmental Microbiology and Biotechnology
8	Outline syllabus	CO Mapping
	UNIT I **Introduction to Microbiology and Genetics**	**CO1/CO4**
	Genetic material, structure, and function, recombinant DNA technology, genetically engineered microorganisms (GEMs), PCR, Gel Electrophoresis, SDS-PAGE, Gene Banks	
	UNIT II **Bioremediation Strategies**	**CO2/CO4**
	Bioremediation, biostimulation, bioaugmentation, phytoremediation, biosorption, an integrated treatment system for biodegradation of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons, pesticides and organic compounds, bio-transformation of heavy metals	

	UNIT III **Fermentation and Enzyme Technology**			**CO3/CO4**
	Bioreactors, batch and continuous reactors, fermentation technology, production, recovery, stability, and formulation of bacterial and fungal enzymes, enzyme kinetics, purification, enzyme assisted bioremediation			
	UNIT IV **Microbial Assisted Recovery**			**CO4/CO4**
	Oil field biotechnology, biomass production, biogas, and biofuel production, microorganisms in mineral and energy recovery, biotechnology for environmental management			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
12	Suggested readings			
	1. *Michael Pelczar, Jr., Microbiology McGraw Hill Education; 5 edition (20 April 2001)* 2. *Pepper, I.L. and Gerba, C.P. Environmental Microbiology - Laboratory Manual. Elsevier, USA. 2005.* 3. *Ratledge, C. and Kristiansen, B. Basic Biotechnology. 2nd ed. Cambridge University Press, Cambridge, UK. 2002.* 4. *Rittman, B. and McCarty, P. L. Environmental Biotechnology: Principles and Applications. 2nd edition. Tata McGraw-Hill, USA. 2000.* 5. *Christon J. Hurst, Ronald L. Crawford, Guy R. Knudsen, Michael J. McInerney, Manual of Environmental Microbiology, 2nd edition, ASM Press. 2001.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**2**	**1**		
CO2	**2**	**3**		**2**	
CO3			**3**		**2**
CO4	**1**	**2**		**2**	**3**
Level: 1-Low; 2-Medium; 3-High					

ENV503: Environmental Toxicology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III**
1	Course Code	**ENV503**
2	Course Title	**Environmental Toxicology**
3	Credits	**4**
4	Course Status	**Core**
5	Course Objective	1. Introduce the basic concepts, approaches and principles of toxicology 2. Understand the dose-response relationship and the main parameters derived from it. 3. Explain the mechanisms of action of environmental toxicants in causing a toxic response in living organisms. 4. Provide fundamental knowledge on fate and transport of toxicants in the environment and how these processes affect their toxicity.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Acquire knowledge relating to the fundamentals in the basic areas of toxicology and understand the discipline's relevancy to real-world issues. **CO2.** Identify relationships between chemical exposure and effects on physiological systems and design strategies for the study of dose-response relationships. **CO3.** Apply the knowledge acquired for evaluating contaminant exposure and risk assessment. **CO4.** Critically evaluate, discuss, explain, and present contemporary topics in environmental toxicology primary scientific literature.
7	Course Description	This course is designed to provide an overview of environmental toxicology, including an examination of the major classes of pollutants, their fate in the environment, their disposition in organisms, and their mechanisms of toxicity. An emphasis will also be placed on assessing the toxicity of pollutants in biological and environmental systems.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1/CO4**
	Definition and scope; History; Principles of toxicology; Toxicant effects; Toxicity tests; Toxicological dose metrics; Dose-response relationship.	
	UNIT II **Toxicokinetics**	**CO2/CO3/CO4**
	Absorption - Routes of toxicants exposure, Gastro-intestinal tract, Respiratory tract, Skin, Mechanisms of transmembrane transport; Distribution - Mechanism, Structural barriers, Storage Depots; Biotransformation reactions – Biotransformation sites, Phase	

	I and Phase II reaction; Excretion – Urinary, Faecal, Respiratory, Other routes of excretion.			
	UNIT III **Ecotoxicology I**			**CO3/CO4**
	Environmental toxicants; Sources – Point and Non-point sources; Transport processes - Advection and Diffusion processes, Equilibrium partitioning; Transformation processes - Abiotic and biotic reactions; Environmental Fate Models.			
	UNIT IV **Ecotoxicology II**			**CO3/CO4**
	Global dispersion and circulating mechanisms of toxicants in the environment; Factors affecting toxicants action; Ecosystem influence on the fate and transport of toxicants; Environmental risk assessment and management.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Haye's A.W. and Kruger C.L., Hayes' Principles and Methods of Toxicology, 6th edition, CRC Press. 2014.* 2. *Hodgson E. A Textbook of Modern Toxicology. 3rd Edition. John Wiley & Sons, Inc. 2004.* 3. *Walker C.H., Sibly R.M., HopkinS.P., Peakall D.B. Principles of Ecotoxicology, 4th ed, CRC Press. 2008.* 4. *Shaw I.C. and Chadwick J. Principles of Environmental Toxicology; Taylor& Francis. 1998.* 5. *Frank C. Lu. Basic Toxicology: Fundamentals, Target Organs, and Risk Assessment, Taylor and Francis. 2003.* 6. *Pepper, I.L. and Gerba, C.P. Environmental Microbiology - Laboratory Manual. Elsevier, USA. 2005.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**		**1**	**1**
CO2	**2**	**3**	**1**		
CO3	**1**			**3**	**2**
CO4		**3**	**3**		**1**
Level: 1-Low; 2-Medium; 3-High					

ENV504: Environmental Laboratory-III (2 Credits)

School: School of Earth Sciences		**Batch: 2020-21**		
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21**		
		SEMESTER III		
1	Course Code	**ENV504**		
2	Course Title	**Environmental Laboratory-III**		
3	Credits	**2**		
4	Course Status	**Core**		
5	Course Objective	1. Provide significant knowledge of biotechnological techniques to modify and augment microorganisms in the laboratory and environment 2. Know various techniques for toxicological responses and exposure to dose matrices.		
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Student will develop an understanding on various microbial methods and biotechnological techniques. **CO2.** Understand the dose response relationships and toxicity testing methods.		
7	Course Description	Designed to provide significant aid and exposure to the students laboratory techniques for environmental biotechnology and toxicology.		
8	Outline syllabus			CO Mapping
	UNIT I **Environmental Biotechnology**			**CO1/CO2**
	Various tools and techniques of environmental microbial biotechnology lab, a survey of microorganisms of water and soil and their morphological identification, isolation of DNA from bacterial cells, multiplication of DNA by PCR technique.			
	UNIT II **Environmental Toxicology**			**CO2/CO2**
	Calculation of LC50, LD50, EC50, ED50, acceptable daily intake (ADI), a margin of safety, therapeutic index, qualitative and quantitative determination of environmental toxicants in different environmental matrices.			
9	Mode of examination	Practical		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. Environmental Biotechnology: Theory and Application Hardcover – Import, 18 October, Wiley-Blackwell, 2002.			

	2. *Environmental Toxicology January 2018,* Pointer Publishers, Jaipur; First edition (2018) 3. *Walker C.H., Sibly R.M., HopkinS.P., Peakall D.B. Principles of Ecotoxicology, 4th ed, CRC Press. 2008.* 4. *Haye's A.W. and Kruger C.L., Hayes' Principles and Methods of Toxicology, 6th edition, CRC Press. 2014.* 5. *Hodgson E. A Textbook of Modern Toxicology. 3rd Edition. John Wiley & Sons, Inc. 2004.*

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**1**	**1**
CO2	**3**	**3**	**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

ENV505: INTERNSHIP/SKILL ENHANCEMENT (2 credits)

School: School of Earth Sciences		**Batch: 2020-21**		
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21**		
		SEMESTER III		
1	Course Code	**ENV505**		
2	Course Title	**INTERNSHIP/SKILL ENHANCEMENT**		
3	Credits	**2**		
4	Course Status	**Core**		
5	Course Objective	1. Learn about environmental initiatives and activities all while being in an national work environment. 2. Development of skills required for environmental analysis and monitoring.		
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Get exposure and experience of myriad environmental problems for research purpose. **CO2.** Able to design basic research plan and required methodologies to conduct the research.		
7	Course Description	Student will be able to apply analytical and various environmental techniques for resolving environmental and ecological problems.		
8	Outline syllabus			
	Visit to research laboratories/minor project during summer vacations (3-4 weeks). Evaluation will be based on report submission and presentation based on their visit to respective laboratories/institutions/industry.			
9	Mode of examination	Report Writing + Presentation		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**3**	**2**	**3**
CO2	**2**	**3**	**3**	**2**	
Level: 1-Low; 2-Medium; 3-High					

Semester IV

ENV506: Dissertation (16 Credits)

School: School of Earth Sciences		**Batch: 2020-21**		
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER IV**		
1	Course Code	**ENV506**		
2	Course Title	**Dissertation**		
3	Credits	**16**		
4	Course Status	**Core**		
5	Course Objective	1. To Identify/define environmental problems existing in the area of interest and generate research questions and/or relevant hypotheses 2. Identify and apply appropriate research methods to deal with the research questions and hypothesis also conduct research responsibly and ethically using good laboratory practices 3. Evaluate, interpret, and analyze a body of empirical data and evidence to generate an empirical model for better understanding and discuss findings and prepare report in the broader context of the field		
6	Course Outcomes	By the end of the course, the student should be able to **CO1.** Able to identified real existing problem and exposure to problem based learning **CO2.** Able to prepare scientific report with clear findings **CO3.** Produce publishable results or generate a decision support system		
7	Course Description	Student will be able to design research work, apply various analytical techniques, writing dissertation thesis and presentation of the research work.		
8	Outline syllabus			
	Each student will work for M. Sc. Project under the supervision of formally assigned supervisor in the department. Student shall complete the process of academic interaction to obtain teachers consent to supervise his/her project work. The work on research project will start under the supervision of assigned faculty member and will be completed by end of 4th semester with submission of dissertation. Dissertation will be evaluated by committee of expert members based on their presentation and viva- voce.			
9	Mode of examination	Dissertation Thesis + Presentation		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	2	
CO2	3	3			1
CO3	3	3	3	2	3
Level: 1-Low; 2-Medium; 3-High					

Elective Courses I

ENV410: Soil Science **(4 Credits)**

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV410**
2	Course Title	**Soil Science**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. Understand the relationships between minerals, rocks, geological processes, and soil formation. 2. Describe the physical and chemical characteristics of the soil. 3. Provide a basic understanding of the influence of underlying geology on soil functions 4. Develop an understanding between soil fertility and plant nutrition.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Describe the various mineral and organic components of soils, including how changes in various quantities affect soil physical and chemical properties. **CO2.** Understand the soil components and the nature of the interactions between these components. **CO3.** Identify the ways to improve soil fertility as well as reduce soil erosion and improve water quality and availability. **CO4.** Understand the issues related to soil resource and management practices.
7	Course Description	This course provides basic knowledge of soil as a resource in both natural and agricultural ecosystems. This introductory course covers processes of soil formation, soil profile development, fundamentals of soil physical and chemical properties, and soil fertility.
8	Outline syllabus	CO Mapping
	UNIT I **Soil Mineralogy**	**CO1/CO4**
	Mineralogical composition of Earth's Crust; Clay minerals - Classification, Structure, Composition, Properties; Soil forming processes; Weathering and pedogenesis; Soil profile; Soil classification systems; Major soil groups of India.	
	UNIT II **Soil Physics**	**CO2/CO4**
	Soil texture and structure; Soil consistence; Density and weight relationship; Soil porosity and aeration; Soil colour; Soil Temperature; Soil water: classification, soil-water potential, water flow in saturated and unsaturated soils.	
	UNIT III **Soil Chemistry**	**CO2/CO4**
	Chemical composition of the earth's crust and soils; Soil colloids: inorganic and organic colloids; Ion-exchange processes; Soil pH; Soil alkalinity and acidity; Saline and sodic soils; Soil organic matter – genesis, classification, humus formation & decomposition.	

	UNIT IV **Soil Fertility**			**CO3/CO4**
	Soil fertility and soil productivity; Nutrient sources; Essential plant nutrients; NPK-sources, forms, immobilization, and mineralization; Fertilizer use efficiency.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	Semester examination
		20%	20%	60%
11	Suggested readings			
	1. *Brady N.C. and Weil R.R. The Nature and Properties of Soil, 14th Ed., Pearson Education. 2007.* 2. *Indian Society of Soil Science. Fundamentals of Soil Science. ISSS, New Delhi. 2002.* 3. *Kim H. Tan. Environmental Soil Science, 3rd Edition, CRC press. 2009.* 4. *Millar C.E., Turk L.M. Fundamentals of Soil Science, 2nd edition, Biotech Books. 2002.* 5. *Mehra R.K. Textbook of Soil Science, Indian Council of Agricultural Research. 2004.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**2**		**2**
CO2	**3**	**2**	**3**	**1**	
CO3	**3**	**2**	**3**	**2**	**2**
CO4	**3**	**2**	**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

ENV411: Agrometeorology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**	
1	Course Code	**ENV411**	
2	Course Title	**Agrometeorology**	
3	Credits	**4**	
4	Course Status	**Elective**	
5	Course Objective	1. To learn meteorological and agrometeorological observations. 2. To learn the process of solar radiation and its influences on crop plants. 3. To learn meteorological hazards and their impact on crop plants and the prevailing solution. 4. To learn available agrometeorological forecast and utilisation in improving crop productivity.	
6	Course Outcomes **(CO)**	**CO1.** Understanding of the meteorological observation and its specific use in agricultural purposes. **CO2.** Understanding the solar radiation and its utilisation by the crop plants. **CO3**. Understanding of the concept of the meteorological hazards and impact on the crops as well as the preventive measure to improve the crop health. **CO4.** understanding of the agrometeorological forecast for improving the crop yield and judicious use of the natural resources in crop productivity.	
7	Course Description	To develop the understanding of the meteorological influences on the crop for better yield and judicious use of the natural resources applicable in crop production.	
8	Outline syllabus		CO Mapping
	UNIT I **Basics of Agro-meteorology and Agrometeorological Observations**		
	Scope, intent and extent of agricultural meteorology, plant physiology, long term and short term modifications of the growth process; Agrometeorological observations: air, surface and soil temperature, air and soil humidity, vapour pressure, wind, precipitation, sunshine, radiation intensity, El Nino, La Nina, ENSO; Earth's energy budget.		CO1 CO1 CO1
	UNIT II **Solar Radiation and Plants**		
	Reflection, transmission and absorption, incoming, outgoing, and net solar radiation; Spectral distribution of solar radiation and physiological response to plants, Light distribution in the plant canopy; Phototropism and Photoperiodism: Effect of meteorological factors on photosynthesis.		CO2 CO2 CO2
	UNIT III **Meteorological Hazards and Agriculture**		
			CO3

	Frost and frost fighting methods, hail damage and hail modification methods.; Wind damage and wind breakers; agricultural drought, its severity and management; Flood, flood damage and flood fighting; Climate extreme change and its impact on agriculture.				CO3 CO3
	UNIT IV	**Agrometeorological Forecast Services**			
	Agrometeorological forecasts systems, short, medium and long-range forecasts; Yield forecasts model, system stimulation its concept, application and importance; Agro-met Advisory services.				CO4 CO4 CO4
9	Mode of examination	Theory			
10	Weightage Distribution	Internal Assessment -I	Internal Assessment -II	End of Semester Examination	
		20%	20%	60%	
11	Text book/s*	*1. Agrometeorology Principles and Applications of Climate Studies in Agriculture by Harpal S. Mavi and Graeme J. Tupper, an imprint of the Haworth Press, Inc., New York/London/Oxford*			
	Other References	*1. Methods in Agricultural Meteorology (Developments in Atmospheric Science) by L. P. Smith: published by Elsevier Science Ltd* *2. Agrometeorology by J. Seemann, Y. I. Chirkov, J. Lomas, and B. Primault: a Springer publication* *3. Agricultural Meteorology by G.S.L.H.V. Prasad Rao: Published by –PHI Learning Private Ltd.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	**3**	**2**		**2**
CO2		**2**	**2**	**1**	
CO3	**3**	**3**	**3**		
CO4	**2**	**3**			**3**
Level: 1-Low; 2-Medium; 3-High					

ENV412: Waste Water Treatment (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV412**
2	Course Title	**Waste Water Treatment**
3	Credits	**4** (2T+2P)
4	Course Status	**Elective**
5	Course Objective	1. To learn about available waste resources and its distribution on earth 2. To understand the science and technologies of wastewater treatment processes and operations. 3. To understand the basic design criteria and the operation of wastewater treatment facilities/plants. 4. To understand the sampling and analytical techniques required for the wastewater characterization and the monitoring of the wastewater treatment plants.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Know different sources of water pollution and their corresponding qualities, linking these to the basic objectives of wastewater treatment **CO2.** Understand the main physical, chemical and biological processes used for wastewater treatment and link them to standards for wastewater effluent disposal. **CO3.** Acquire knowledge on the facilities and provisions required for the handling and management of the wastewater treatment sludges **CO4.** Learn methods for water resource recovery and reuse
7	Course Description	To develop a basic understanding of wastewater treatment and management
8	Outline syllabus	CO Mapping
	UNIT I **Overview of Water Resources**	**CO1/CO4**
	Global distribution of water resources, water need (domestic, industrial and agricultural) and consumption, sources of pollution: surface water (river and lakes), ground water and coastal water, precipitation in India (rainfall), water quality data processing, seawater intrusion	
	UNIT II **Wastewater Characteristics**	**CO2/CO4**
	Water quality, standards for drinking water and wastewater, major sources of water pollution, physicochemical and biological properties of sewage, quality of industrial effluents produced from textile, dairy, leather, thermal power, and chemical industries etc.	
	UNIT III	**CO3/CO4**

	Treatment Technologies			
	Sewage treatment: pre-treatment, primary, secondary, and tertiary treatment methods. Activated sludge, oxidation ponds, trickling filter, Rotating Biological Contactors, UASB reactors, water disinfection methods. Treatment plants- STP and ETP			
	UNIT IV **Recovery methods**			**CO4/CO4**
	Concept of 4 R's (reduce, reuse, recycle, recover) recycling of wastewater, recycling of industrial effluent after treatment, sludge recycling, and reuse.			
	Laboratory: Collection, storage and preservation of wastewater samples, microbiological examination of wastewater, determination of oil and grease, determination of various physic-chemical parameters of wastewater, biochemical oxygen demand, chemical oxygen demand, estimation of major cations, anions, heavy metals and organic contaminants present in wastewater using spectrophotometric/chromatographic methods.			
9	Mode of examination	Theory and Practical		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. Tchobanoglous G., Burton F.L. and StenselH. D. Wastewater Engineering: treatment and Reuse. 4th ed. Metcalf and Eddy Inc., New York, NY: McGraw-Hill, 2003. *2. Qasim S.R., Motley, E.M. and Zhu.G. Water works Engineering – Planning, Design and Operation, Prentice Hall, New Delhi, 2002.* *3. Lee C.C. and Shun dar Lin, Handbook of Environmental Engineering Calculations, Mc Graw Hill, New York, 1999.* *4. Hendricks D. Water Treatment Unit Processes – Physical and Chemical, CRC Press, New York, 2006.* *5. Staff M.W.H. Water Treatment: Principles and Design. 2nd ed. New York, NY: Wiley, 2005.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	**3**	**3**		
CO2		**3**		**2**	**2**
CO3	**1**		**2**		**3**
CO4			**3**		**3**
Level: 1-Low; 2-Medium; 3-High					

ENV413: Environmental Disasters and Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV413**
2	Course Title	**Environmental Disasters and Management**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. Impart basic concepts of disaster, its causes, and its historical background. 2. Enhance student's knowledge about disaster management planning. 3. Make the students learn advanced approaches to deal with disaster management. 4. To understand approaches of Disaster Risk Reduction with the relationship among disaster vulnerability, prevention, and risk reduction.
6	Course Outcomes **(CO)**	**CO1.** Explain various types of Environmental disasters and responsible factors. **CO2.** Interpret and discriminate different stages of disaster management planning and utility tools in every stage. **CO3.**Understand the administrative structure of disaster management in India and know the ethical and humanitarian values. **CO4.**Apply advanced techniques in disaster management and disaster risk reduction.
7	Course Description	The course is intended to provide a concept in the dimensions of disasters caused by nature as well as the environmental hazards induced by human activities with an emphasis on disaster preparedness, response, and recovery.
8	Outline syllabus	CO Mapping
	UNIT I **Definition and types of disaster**	**CO1/CO4**
	Hazards and Disasters, Risk and Vulnerability in Disasters, Natural and Man-made disasters, earthquakes, floods drought, landslide, land subsidence, cyclones, volcanoes, tsunami, avalanches, global climate extremes, Disease epidemics or pandemics, Man-made disasters: Terrorism, gas and radiations leaks, toxic waste disposal, oil spills, forest fires etc.	
	UNIT II **Disaster Recovery, Rehabilitation and Reconstruction**	**CO2/CO4**
	Concept, Meaning, Types of Rehabilitation and Reconstruction, Importance of Disaster Mitigation, Cost-benefit analysis, the relationship between vulnerability and development Damage Assessment, Epidemiological Surveillance, Nutrition Centred Health Assessment.	
	UNIT III **Disaster Mitigation and Management techniques**	**CO3/CO4**

	Basic principles of disaster management, Disaster Management cycle, Disaster management policy, National and State Bodies for Disaster Management, Early Warming Systems, Building design and construction in highly seismic zones, retrofitting of buildings.			
	UNIT IV Advanced Techniques in Disaster Management			**CO4/CO4**
	Early Warning System, Core Components of Emergency Communication System, Wireless Communication, Remote Sensing and GIS Applications in pre and post-disaster management, Risk Assessment and Vulnerability Analysis, GPS Applications in Emergency Communication.			
	Mode of Exam	**Theory**		
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
	Suggested readings:			
	1. *Disaster Management Guidelines, GOI-UND Disaster Risk Program (2009-2012)* 2. *Damon, P. Copola, (2006) Introduction to International Disaster Management, Butterworth Heineman.* 3. *Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster Management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.* 4. *Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication PVT. Ltd. New Delhi.* 5. *Modh S. (2010) Managing Natural Disasters, Mac Millan publishers India LTD. Waugh, William L. Jr. (2000). Living with Hazards, Dealing with Disasters: An Introduction to Emergency Management. Armonk, New York: M.E. Sharpe.* 6. *Burby, Raymond (1998). Cooperating with Nature: Confronting natural hazards with land-use planning for sustainable communities. Joseph Henry Press.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**	**1**	**2**
CO2	**2**		**2**	**2**	**3**
CO3		**2**		**3**	**2**
CO4	**2**	**2**		**3**	**3**
Level: 1-Low; 2-Medium; 3-High					

ENV414: Solid Waste Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**			
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**			
1	Course Code	**ENV414**			
2	Course Title	**Solid Waste Management**			
3	Credits	**4**			
4	Course Status	**Elective**			
5	Course Objective	1. To understand the methods available for solid waste disposal. 2. To evaluate the health risks posed by abandoned waste sites and waste disposal operations. 3. To understand the Life cycle inventory of Solid Waste Management. 4. To evaluate the legislation designed to control the production, cleanup and disposal of solid and hazardous waste disposal operations.			
6	Course Outcomes **(CO)**	**CO1.** The students would understand the hierarchical structure in solid waste management and the need for a sustainable solution. **CO2.** To characterize the solid waste qualitatively as well as quantitatively for better management approaches. **CO3.** To integrate GIS techniques for the identification of better site and development of better management plans. **CO4.** To understand the main aspects of waste policy and regulations and would be able to come up with significant policy interventions needed.			
7	Course Description	To provide a framework for learning about sampling needs, procedures and techniques along with detailed understanding of modern laboratory instruments.			
8	Outline syllabus				CO Mapping
	UNIT I **Introduction**				CO1/CO2
	Concerns over waste, current approaches – legislation, solid waste generation and composition, waste collection, central sorting				
	UNIT II **Treatment Options**				CO2/CO3
	Biological treatment, thermal treatment, landfilling, materials recycling				
	UNIT III **Management Options**				CO3/CO4
	Integrated waste management, development of integrated waste management systems: case studies and their analysis				
	UNIT IV **Life cycle assessment**				CO4
	Life cycle inventory of solid waste, LCI case studies, life cycle inventory model for integrated waste management				
	Mode of examination	Theory			
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination	

		20%	20%	60%
	Suggested Readings	*1. George Tchobanoglous G. and Kreith F. Handbook of Solid Waste Management, Butterworth-Heinemann, 2003.* *2. Zhu D., AsnaniP.U., Zurbrügg C. and Anapolsky S.Improving Municipal Solid Waste Management in India, World Bank, 2007.* *3. White P., Franke M. and Hindle P. Integrated Solid Waste Management: A Life Cycle Inventory; Springer, 2011.* *4. Reddy P.J. Municipal Solid Waste Management, CRC Press, 2011.* *5. Chandrappa R. and Das D.B. Solid Waste Management, Springer, 2012.*		

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**1**	**2**
CO2		**3**		**2**	
CO3	**2**	**3**	**3**		**3**
CO4	**2**	**2**	**2**	**3**	**2**
Level: 1-Low; 2-Medium; 3-High					

ENV415: Natural Resources, Biodiversity and Wildlife Conservation (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV415**
2	Course Title	**Natural Resources, Biodiversity and Wildlife Conservation**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective **(CO)**	1. To impart knowledge to become part of professional organizations working in the field of conservation and environmental protection. 2. To generate a skilled postgraduate who can research in the field of Biodiversity, Wildlife biology, and nature conservation. 3. To provide an alternate avenue for students to specialize as "environmental entrepreneurs" in areas such as environmental audits, Environmental education, Ecotourism, etc. 4. To create awareness about Biodiversity and Nature Conservation.
6	Course Outcomes	By the end of the course, the student should be able to understand **CO1.** Students will be competent in basic natural resources. **CO2.** Students will gain knowledge of the components of natural resources. **CO3.** Students will be able to apply knowledge to solve problems related to Biodiversity conservation and management. **CO4.** Students will be able to write in a style appropriate for technical or informative publications for various audiences related to wildlife & natural resources conservation and management.
7	Course Description	This course will encompass an overview of natural resources, biodiversity and conservation globally and in particular with the Indian context. Further, this will deal with the policies and awareness about biodiversity and conservation.
8	Outline syllabus	CO Mapping
	UNIT-1 **Introduction to Natural Resources**	**CO1/CO4**
	Concept and classification of natural resources, valuation of natural resources, Factors influencing resource availability, distribution, and uses. Inter-relationships among different types of natural resources. The ecological, social, and economic dimensions of resource management.	
	UNIT II **Forest, Water, Mineral, Food, ~~and~~ Land Resources and Energy**	**CO2/CO4**
	Forest as a natural resource: importance, services, and classification; forest resources in India; forest fragmentation; deforestation and conservation strategies; Compensatory	

	Afforestation Forestry programmes – social forestry, community forestry, farm forestry, extension forestry; water resources: Use and over-utilization of surface and groundwater, floods, drought, conflicts over water, dams-benefits and problems (c) Mineral resources: Use and exploitation and environmental effects; (d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture. Case studies; Land resources: Land as a resource, land degradation, anthropogenic landslides, soil erosion, and desertification, (e) Energy resources: Growing energy needs, renewable, and nonrenewable energy sources use of alternate energy sources.			
	UNIT III **Biodiversity Patterns and Wildlife**			**CO3/CO4**
	Concept of heterogeneity, species richness, alpha, beta and gamma diversity, Global patterns of biodiversity. Hypotheses of ecological and evolutionary factors influencing diversity. The economic value of biodiversity, biodiversity losses. Biogeographical classification of India. IUCN criteria of endangerment, Red Data Book, Threatened plants and animals of India, Endemic species, Hotspots of biodiversity, Megabiodiversity countries, Diversity indices, Biopiracy. Wildlife distribution in India, Wildlife protection: role of WWF, WCU, CITES, TRAFFIC. Equity in Benefit sharing as per NBA act, IPR issues related to biodiversity, Basic of DUS characterisation.			
	UNIT IV **Biodiversity Conservation**			**CO4/CO4**
	In-situ conservation: sanctuaries, biospheres reserves, national parks, nature reserves, preservation plots. In-vitro Conservation: germplasm and gene Bank; tissue culture: pollen and spore bank, DNA bank. Ex-situ conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; Convention on Biological Diversity, United Nations Decade on Biodiversity 2011-2020, National Biodiversity Action Plan in India (NBAP).			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. Daniel, D., Chiras and Reganold, John P. Natural Resource Conservation: Management for a Sustainable Future (X Ed.), Addison Wesley, Boston. 2009. *2. Singh, N. Irabanta. Endemic Bioresources of India, Bishan Singh Mahendra Pal Singh, Dehradun. 2008.* *3. Enger, E.D. and Smith, B.F. Environmental Science: A Study of Interrelationships. 11th ed. McGraw Hill Inc., USA. 2006.* *4. Heywood, V.H. and Watson, R. T. Global biodiversity Assessment. UNEP-Cambridge, 1995.* *5. Hunter, Malcolm L., Jr., and Gibbs, James P. Fundamentals of Conservation Biology. 3rd ed. Wiley-Blackwell. 2006.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	3	3		2	1
CO2	3	2	2		
CO3	3	3	3	2	2
CO4			3	2	3
Level: 1-Low; 2-Medium; 3-High					

ENV416: Coastal and Marine Environment (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**	
1	Course Code	**ENV416**	
2	Course Title	**Coastal and Marine Environment**	
3	Credits	**4**	
4	Course Status	**Elective**	
5	Course Objective	1. To develop an understanding of the dynamic processes that affect oceans i.e. water, seafloor, and abundant life forms. 2. To understand the role being played by ocean-atmosphere interaction in the climate processes. 3. To understand the role of ocean processes in the coastal and marine landform creation	
6	Course Outcomes **(CO)**	**CO1.** The students will understand the role of physical processes in the dynamic process of ocean circulation. **CO2.** The students will be able to formulate solutions ailing the current state of the coastal and marine environment in terms of chemical and biological interactions. **CO3.** The students will be able to use the knowledge base to promote ocean awareness in the light of human exploitation of its resources.	
7	Course Description	To give an overview of the ocean environment with an emphasis on the interrelationship of the sub-disciplines of ocean sciences.	
8	Outline syllabus		CO Mapping
	UNIT I **Introduction**		CO3
	The origin of the ocean, history of marine science, morphologic and tectonic domains of the ocean floor; ocean basins, ocean sediments		
	UNIT II **Physical and Chemical dynamics**		CO1/CO2
	Composition of seawater, carbon dioxide-carbonate system; dissolved nutrients in the sea (N, P, Si, Fe) and their variability; biological pump, waves, tides, estuaries; Ekman spiral, upwelling, primary and secondary production		
	UNIT III **Atmosphere-Ocean Interaction**		CO1/CO2
	Atmospheric circulation, ocean circulation, formation of bottom waters, El-Nino; La-Nina; ENSO, NAO, PDO		
	UNIT IV **Ocean Resources and retrieval**		CO3
	Sampling instruments in a marine environment (water sampler, reversing thermometer, grab sampler, high productive region, coral reef, eutrophication of coastal water and algal bloom causes, consequence, and remedial measures),		

	use of seawater (desalination and cooling water); life in the ocean, pelagic communities, benthic communities, uses and abuses of the ocean			
	Mode of examination	Theory		
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
	Suggested Readings	*1. Garrison Tom S. Essentials of Oceanography 5th ed. Belmont, Brooks/Cole, Cengage Learning. 2009.* *2. Paul R. Pinet.Introduction to Oceanography: Jones & Bartlett Learning. 2011.* *3. Alan P. Trujillo and Harold V Thurman. Essentials of Oceanography, Prentice Hall. 2013.* *4. Lalli M.C. and Parsons T.R.Biological Oceanography: An Introduction, Elsevier. 2012.* *5. Frank J. Millero. Chemical Oceanography, CRC Press. 2014.*		

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**			
CO2		**2**	**3**	**1**	**2**
CO3	**3**		**2**		**3**
Level: 1-Low; 2-Medium; 3-High					

ENV417: Environmental Legislation (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV417**
2	Course Title	**Environmental Legislation**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. To acquaint the students with the environmental issues, pollution, and control and the measures taken for its protection along with the prevailing norms. 2. To develop an understanding of the prevailing national and international provisions of environmental policies and legislations.
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Get basic knowledge of environmental policies, its relevance, and various principles. **CO2.** Understand various acts and legislation in place and suggest solutions of the gaps in the existing policies and legislation. **CO3.** Know about international treaties and conventions **CO4.** Know the significance of various historical environmental movements.
7	Course Description	To develop a basic understanding of Environmental policy and Legislation
8	Outline syllabus	CO Mapping
	UNIT I **Environmental Policy**	**CO1/CO4**
	National Environmental Policy, National Policy on EIA and Regulatory framework, State Environmental issues and policy framework. Constitutional Provisions (Article 48A, 51A). Role of Ministry of Environment & Forests, Central and State Pollution Control Boards.	
	UNIT II **Acts, Rules and Regulations**	**CO2/CO4**
	Wildlife (Protection) Act 1972, Water (Prevention and Control of Pollution) Act 1974; Forest Conservation Act 1980, Environment (Protection) Act 1986, the Environmental Protection Act & Environmental rules 1986. Air (Prevention and Control of Pollution) Act 1981; Bio-Medical Waste (Management & Handling) Rules, 1998; Hazardous Waste (Management, Handling Rules, 1989); Transboundary Movement Rules, 2008. Plastics manufacture, Sale and Usage Rules, 1999. Coastal Regulation Zones (CRZ) Rules 1991. Public Liability Insurance Act, 1991. Rules, Regulations and Guidelines for Municipal Solid Waste [MSW]; Electronic Waste [EW].	
	UNIT III **Environmental Treaties and Conventions**	**CO3/CO4**

	Evolution and development of International Environmental laws with reference to Stockholm conference on Human Environment, 1972, Ramsar Convention on Wetlands, 1971, Montreal Protocol, 1987, Basel Convention (1989, 1992), Earth Summit at Rio de Janeiro, 1992, UNEP, GEF, UNFCC and IPCC, Kyoto Protocol, 16 1997; Earth Summit at Johannesburg, 2002. UN Summit on Millennium Development Goals 2000			
	UNIT IV **Environmental Ethics and Landmark Judgments**			**CO4/CO4**
	Value education, individual, community, corporate social responsibility. Movements related to Environment – Sacred groves, Bishnoi tradition, Chipko movement, Tehri dam, Sardar Sarovar, Narmada dam, Almatti dam, Silent Valley. Role of NGOs. Sustainable Development: Definition and concepts. Supreme Court directive on the introduction of the subject of environmental studies at different levels, the introduction of CNG in public transport. Compensatory Afforestation. Environmentally Significant Days.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. Shelton D. and Kiss A. C. Judicial Handbook on Environmental Law, United Nations Environment Programme, 2005. 2. Jaswal, P.S. and Jaswal, N. Environmental Law. Pioneer Publications, Delhi. 2003. 3. Tiwari, R. K. Global Environmental Policies. ABD Publishers, 2007. 4. Trivedy R. K. Handbook of Environmental Laws, Guidelines, Compliance & Standards, Vol. 1 & 2 Environ – Media Karad, India, 2004. 5. Kuttingayloan G. M. Conventions, Treaties and other Responses to Global Issues, Vol. 1 & 2 EOLSS Publishers Co Ltd, 2009.			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1		**2**		**3**	**2**
CO2	**2**		**3**	**3**	**2**
CO3		**2**	**3**	**3**	**2**
CO4	**2**		**3**	**3**	**2**
Level: 1-Low ; 2-Medium; 3-High					

ENV418: Energy and Environment (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV418**
2	Course Title	**Energy and Environment**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. To understand the physical principles underlying Earth's energy and interaction with the environment. 2. To understand the effect of the implementation of environmental technologies and policies on sustainable energy usage. 3. To understand the broader view of energy, environment and climate change impacts. Global and national issues.
6	Course Outcomes **(CO)**	**CO1**.Students would be able to exhibit an ability to integrate major factors affecting the Earth's energy resources, environment, and climate change. **CO2.** The students would be able to demonstrate expertise in energy supply and demand. Understanding technologies for sustainable energy usage. **CO3.** Conservation of energy, alternate energy efficiency, security and their association with environmental effects in a global and societal context. **CO4.** The students would exhibit innovative and creative solutions to energy and environmental problems through projects.
7	Course Description	Understanding of Earth's energy resources, usage and issues related to energy and the environmental challenges.
8	Outline syllabus	CO Mapping
	UNIT I **Energy Basics**	**CO1**
	Energy basics and significance; Heat budget of the earth; Global energy flow pattern, usage, energy demand and current and future perspectives; Scope and analysis impacts of energy usage on the environment; Mechanism of radiation action on living systems-stochastic and non-stochastic effects.	
	UNIT II **Energy Resources**	**CO2**
	Conventional and non-conventional energy sources: Fossil fuels-coal, oil and natural gas, biomass; Hydroelectric power; tidal energy, wind energy, geothermal energy, magneto-hydrodynamics; Hydrogen energy; Solar collectors, photovoltaics, solar ponds; Nuclear-fission and fusion.	
	UNIT III **Energy Conservation**	**CO3**

	Energy conservation and management local to global scales; Alternate energy generation system, efficiency, utilization and assessment; Impact of large scale exploitation of solar, wind, hydro and other renewable energy sources.			
	UNIT IV **Global Energy Scenario**			**CO4**
	Environmental implications of energy use; Energy use pattern in India and the world, renewable energy potential in India; Emissions of CO_2 and other greenhouse gases in developed and developing countries including India.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Andrew R.W., Jackson & Julie M. Jackson, Environmental Science – The Natural Environment and Human Impact, Addison Wesley Longman Limited, 1996.* 2. *David Elliott, Sustainable Energy, Opportunities and Limitations, Sustainable Energy: Opportunities and Limitations (Energy, Climate and the Environment) Publisher: Palgrave Macmillan; 2007* 3. *David Baker, General Chemistry, 5th edition, Darrell D. Ebbing. Houghton Mifflin: Boston, 1996* 4. *Santra, S.C. Environmental Science, 3rd Edition, New Central Book Agency (P) Ltd, Kolkata, India, 2011.* 5. *United Nations Scientific Committee on Effects of Atomic Radiation Report 2000, New York, USA, 2000.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**3**	**2**	**2**
CO2	**3**	**2**	**2**		**2**
CO3	**3**	**2**	**2**	**2**	**2**
CO4	**2**	**3**	**1**		**1**
Level: 1-Low; 2-Medium; 3-High					

ENV419: Environmental Impact Assessment and Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV419**
2	Course Title	**Environmental Impact Assessment and Management**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. To explain the basic principles of environmental impact assessment 2. To understand the different steps within environmental impact assessment. 3. To discuss the implications of current jurisdictional and institutional arrangements in relation to environmental impact assessment 4. To understand how to liaise with and the importance ofstakeholders in the EIA process 5. To be able to access different case studies/examples of EIA in practice
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Understand the basics of EIA and legal implications **CO2.** Understand the strategic and organizational context of environmental management in different settings and design and deliver practical outcomes that contribute positively to environmental performance. **CO3.**Synthesize and prioritize information from desktop and field environmental assessments, rank the relative values identified, assess the risks imposed by the development, and determine appropriate environmental management strategies. **CO4.** Articulate and justify specific policies or courses of action on complex environmental issues using discipline based knowledge and established management principles.
7	Course Description	To develop a basic understanding of Environmental Impact Assessment
8	Outline syllabus	CO Mapping
	UNIT I **Overview of EIA**	**CO1/CO4**
	Objectives and development of EIA. Benefits of EIA, Indian directions of EIA**.** Rapid and comprehensive EIA perspectives. Sources and collection of data for EIA. EIA notifications, Environmental Clearance	
	UNIT II **EIA Methodology**	**CO2/CO4**

	Screening, Scoping, Purpose of scoping, Baseline studies intrinsic and external database supports and interpretation; checklist, matrices, Overlays and Geographical Information System, Impact analysis and Predictions, Environmental Impact Statement [EIS]; EIA report. EIA of Cement Industry, Thermal Power Plant, Mining, Nuclear Power Plant, Pesticide Industry, Highways, Hotels, Townships, etc.			
	UNIT III **Environmental Management and ISO Certification**			**CO3/CO4**
	Environmental Management Systems (EMS), ISO 14000 (EMS). Components of Environmental Management System-Objectives, Policies, Implementation and Review. Life Cycle Analysis –LCA. Environmental appraisal, accounting and environmental audit			
	UNIT IV **Public Participation**			**CO4/CO4**
	Concept and significance of Public Hearing, Social impact assessment (SIA), Strategic Environmental Assessment (SEA), post project analysis restoration and rehabilitation methodologies, Mitigation criteria, Project modification			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Anjaneyulu, Y. and Manickam, V. Environmental Impact Assessment Methodologies. B.S. Publications. 2002.* 2. *Cutter, S. L. Environmental Risks and Hazards. Prentice Hall of India, New Delhi. 1999.* 3. *Glasson, J. Therivel, R. and Chadwick, A. Introduction to Environmental Impact EIA. Routledge, London. 2006.* 4. *Morris, P. and Therivel R. (Eds) Methods of Environmental Impact Assessment. 2nd ed, Spon Press London. 2001.* 5. *Rao, P. S. and Rao, P.M. Environmental Management and Audit. Deep and Deep Publications. 2000.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1		**2**		**3**	**1**
CO2	**2**			**3**	**1**
CO3		**2**	**2**	**3**	**2**
CO4		**3**		**3**	**2**
Level: 1-Low; 2-Medium; 3-High					

ENV420: Global Climate Change Science (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV420**
2	Course Title	**Global Climate Change Science**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. Educate students about the science of climate and climate change 2. Provide information about the international organization for the mitigation of climate change
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to- **CO1.** Explain the fundamentals of climate and climate change science **CO2.** Describe the expected consequences of climate change and the role of mitigation and adaptation. **CO3.** Understand the climate model and projections for future studies **CO4.** Understand the functioning of an international organisation working for the cause of climate change.
7	Course Description	This course will include the basic climate and climate change science in addition to an international organization working for the cause of mitigation of climate change. It will also cover the processes of global warming and climate change and its consequence of climate change.
8	Outline syllabus	CO Mapping
	UNIT I **Overview of Climate and Radiation Budget**	**CO1 /CO4**
	Description of the climate system, components of climate and meteorology, natural greenhouse effect, albedo, the effect of trace gases and aerosols, feedbacks in the climate system, heat flux and radiation budget, radiative enforcing and global warming potential of trace gases	
	UNIT II **Climate change and climate model**	**CO1,CO2/CO4**
	Climate change in the past, ice ages, proxy records, abrupt climate change, Instrumental record of climate, climate variability on various time-scales, simple models of climate, General Circulation Models, Projections and scenarios	
	UNIT III **Consequences of climate change**	**CO2,CO3/CO4**
	Impacts of climate change on the oceans, natural resources, EL-NINO & LA-NINO, economy (agriculture, fisheries and industries etc.), biodiversity and human health. Problems of food, energy and environment due to climate change	
	UNIT IV **International organization on climate issues**	**CO2,CO4/CO4**

	Mitigation of climate change using tools of science, technology and policy frameworks. Sustainability, International organization- WMO, UNEP, UNO, UNDP, UNFCC, IUCN and IPCC.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	Recommended Reading 1. *Baird, C., and Cann, M., Environmental Chemistry, W.H. Freeman and Company, 2008.* 2. *Botkin, Daniel B. and Keller, Edward A. Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA. 2007.* 3. *Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science. Enquiry and Applications. 2nd ed. Tata McGraw Hill, New Delhi. 2004.* 4. *De, A.K., Environmental Chemistry, New Age International (P) Ltd. Publishers, New Delhi. 2000.* 5. *Manahan, S. Environmental chemistry. CRC press, 2017.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**		**3**		**2**
CO2		**3**		**2**	
CO3	**2**		**3**		**2**
CO4		**3**		**1**	
Level: 1-Low; 2-Medium; 3-High					

ENV421: Forest Ecology and Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV421**
2	Course Title	**Forest Ecology and Management**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. To provide an overview of the state of the art in the fields of forest ecology and forest management. 2. To train the students in identifying, analysing and solving various problems using various forestry approaches. 3. To impart the students with a strong base of knowledge that makes them suitable both for industries, teaching and research 4. To inculcate the students towards public policies and their responsibilities towards the conservation of forest resources for the society.
6	Course Outcomes **(CO)**	**CO1.** Ability to apply of knowledge obtained in forest management and environment protection **CO2.** Ability to use methods of the evaluation of negative impacts of human activities on forest ecosystems. **CO3.** Knowledge of system analysis principles at the evaluation of the forest ecological stability. **CO4.** Knowledge on the structure, processes and functioning of forest ecosystems
7	Course Description	The course will focus on the knowledge of the structure, processes and functioning of natural and managed forests, evaluation of ecological impacts of human activities on forest ecosystems and global aspects of forest protection.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction to Forest Ecology**	**CO1/CO4**
	Basic Terminology, Definitions, Importance of Ecology, Global Distribution of Forests, Structure & Functions of Forest Ecosystems, Carbon cycle & productivity, Processes of Biomass Accumulation, NPP & GPP, Global Climatic Changes & Biomass, Applications in Ecology and Forestry	
	UNIT II **Biogeochemical Cycles in Forest Ecosystem**	**CO2/CO4**
	Biogeochemical cycling, Principles & definitions, Essential elements, Mineral Nutrition of Forest Trees, Sources & Uptake of Nutrients, Storages & internal Recycling, Decomposition processes, Mineralization, Importance of Humus, Nutrient use Efficiency, Mass balance and modelling.	

	UNIT III **Ecological stability and ecosystem interaction**			**CO3/CO4**
	Stress theory, Identification of stress factors, Susceptibility & response of forest to Disturbance, Ecological Stability, Resilience vs. Resistance, Adaptation, Main Hypotheses of Forest Decline, Ecosystem Rehabilitation, Applications in Ecology and Forestry.			
	UNIT IV **Forest Management Practices**			**CO4/CO4**
	Forest Fire Ecology & Fire Management, Forest Disease Management, Forest-climate Interaction & Global Climatic Changes, Forest Sustainability, Global Forest Biodiversity & Conservation, Other Ecological and Societal aspects of Forests Protection & Management.			
	Mode of Exam	**Theory + Practical**		
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End Semester Examination
		20%	20%	60%
	Suggested readings:			
	4. Avery, T.E. and Burkhart, H.E. 2002. Forest Measurements. McGraw-Hill. *5. Bardgett, R.D. and Wardle, D.A. 2010. Aboveground-belowground linkages. OxfordUniversity Press, Oxford. ISBN: 978-0-19-954688-6* *6. Barnes, B. V., Zak, D.R., Denton, S.R. and Spurr, S.H. 1998. Forest Ecology – 4thEdition. John Wiley and Sons, Inc. New York, NY. ISBN: 0-471-30822-.* *7. Bettinger, P., Boston, K., Siry, J.P. and Grebner, D.L. 2009. Forest Management and Planing. Elsevier, Amsterdam.* *8. Coomes, D.A., Burslem, D. F.R.P. and Simonson, W.D. 2014. Forests and Global Change. Cambridge University Press, New York. ISBN 978-1-107-61480-2.* *9. Forman, R.T.T. 2014. Urban Ecology: Science of Cities. Cambridge University Press, Cambridge. ISBN: 978-0-521-18824-1.* *10. Kimmens, J.P. 2004. Forest Ecology: a foundation for sustainable management – 3rd Edition. Prentice Hall. Upper Saddle River, NJ. ISBN: 0-02-364071-* *11. Landsberg, J., and R. Waring. 2014. Forests in Our Changing World: New Principles for Conservation and Management. Island Press, Washington, D.C., U.S.A. 224 pp. ISBN 978-1-610-91496-3.* *12. Larocque, G. R. (Edt). 2016. Ecological forest management handbook. CRC Press, Boca Raton, FL. ISBN: 978-1-4822-4785-5.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**2**	**2**	**1**	**2**
CO2	**2**	**3**		**2**	
CO3	**3**	**3**	**2**		**2**
CO4	**3**	**3**	**2**		**2**
Level: 1-Low ; 2-Medium; 3-High					

ENV422: Sustainable Agriculture and Environmental Practices (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV422**
2	Course Title	**Sustainable Agriculture and Environmental Practices**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. To understand the principles underlying sustainable agriculture and interaction with the environment. 2. To understand the effect of the implementation of environmental technologies and policies on sustainable agriculture. 3. To understand the broader view of Climate change impacts related to global and national issues.
6	Course Outcomes **(CO)**	**CO1.** Students will gain an understanding of the environmental problems caused by conventional agriculture, and understand alternative sustainable agriculture to combat the threat of food security. **CO2.** The student will understand resource management required for the agriculture system. **CO3.** Understanding the utilization of alternate energy production from the agriculture sector integrate with environmental impact. **CO4.** Students will learn the importance of agri-environmental policies used to agricultural production and different types of ecosystem services and biodiversity.
7	Course Description	Skills and knowledge related to the sustainability of agricultural production and food security.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1/CO4**
	Definition and concept of sustainable agriculture; Effect of climate change on agricultural production; Threat to food security local to regional scales to global scales; Impacts of agricultural practices on the environment and benefits of sustainable farming.	
	UNIT II **Agriculture Resource Management**	**CO2/CO4**
	Agricultural management of biogeochemical cycles; Sustainable land use in agriculture, soil fertility and water resources management; Integrated pest management; Crop disease identification and protection; Biofertilizers.	
	UNIT III **Energy and Agriculture**	**CO3/CO4**

	Energy production in the agricultural sector, Biofuels and land use, efficiency, and dependency of energy sources in agroecosystems; Effect of biofuels on the environment; current and future perspectives of biofuels			
	UNIT IV **Economic Benefits and Food Security**			**CO4/CO4**
	Economic benefits of sustainable agriculture in crop production, Biodiversity in terms of crops, plant protection; Nutrient utilization and recycling; food, fuel, water, recreation and other ecosystem services.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Nagothu, Udaya Sekhar, Agricultural development and sustainable intensification : technology and policy challenges in the face of climate change, 2018* 2. *M A Khan, Water Resources Management and Sustainable Agriculture, 2008* 3. *James F. Power and Rajendra Prasad. Soil Fertility Management for Sustainable Agriculture,1997* 4. *Bhoopander Giri, Ram Prasad, Qiang-Sheng Wu, Ajit Varma (Editor) Biofertilizers for Sustainable Agriculture and Environment, 2019* 5. *Bharat Singh (Editor) Biofuel Crop Sustainability (Biomass and Biofuels), 2013* 6. *Stephen R. Gliessman, Agroecology: The Ecology of Sustainable Food Systems, Third Edition 3rd Edition, Kindle Edition, 2014*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**2**		**2**
CO2	**3**	**2**	**2**		
CO3		**3**			**2**
CO4	**1**		**2**	**1**	
Level: 1-Low; 2-Medium; 3-High					

ENV423: Environmental Statistics and Computer Programming (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER I/II** **Year I**
1	Course Code	**ENV423**
2	Course Title	**Environmental Statistics and Computer Programming**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. Understanding the implications of computer programming and statistics in environmental data analysis 2. Giving exposure to students about the computer programming skills and basic statistics used for the environmental and ecological data 3. Learning hypothesis testing and trend analysis skills used for the climate, environmental and ecological sciences
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Students will understand the use of the computer programming and statistics for future research and monitoring programmes in environment, climate and ecology sector **CO2.** Students will be able to judge the appropriate methods for the data analysis **CO3.** Students will be able to understand the concept of modelling **CO4.** Students will be able to develop skills required for the interdisciplinary problems and searching solution through multidisciplinary learning in environmental science
7	Course Description	The course is designed to provide significant aid and exposure to the students for the statistics and basic computer programming required for the environmental analysis of the variables/data, besides, to present and validate the hypothesis.
8	Outline syllabus	CO Mapping
	UNIT I **Data distribution and descriptive statistics**	**CO1,CO2,CO3/CO 3**
	Distribution of the data, Important discrete and continuous distributions, Normal distribution, Poisson's distribution, Random variables, Moments, Expectance operator, Gaussian statistics, transformations of random variables and significance of data transformation techniques, descriptive statistics, point and interval estimation, errors and outliers in the data, descriptive statistics, Mean, mode median, variance, standard error, standard deviation, identification of outlier.	
	UNIT II **Statistical hypothesis testing**	**CO1, CO3/CO3**

	Tests of hypotheses, regression, Analysis of variance (ANOVA), t-test, significance and level of confidence, testing the null hypothesis, Student's T, Fischer's Z, and F-test, Goodness-of-fit tests (KS, Chi-squared. One-way ANOVA and two-way ANOVA. Examples and exercise for the one way and two-way ANOVA to test the hypothesis.			
	UNIT III **Regression and relationships of variables**			**CO1, CO3/CO3**
	Regression, Different possible correlation among environmental variables, Correlation (Pearson's rho, Kendall's tau), Goodness-of-fit tests (KS, Chi-squared) example, and exercise of correlation, trend analysis, etc. Examples of environmental data analysis.			
	UNIT I V **Essential Computer programming for statistics**			**CO1, CO2, CO3/CO3**
	Computer programming- basic computer language required for the modelling, R for the environmental analysis, introduction to statistical packages. Program statements, variables, operators, functions, and input/output, Program structure, computer program debugging, Vector variables, creating plots and graphs, Relational operators, if end structures, Switch structures and while loops, Elementary statistical analysis and histograms, Error propagation and statistical correlation, Data import and export, curve fitting.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	Recommended Readings *1. Environmental Statistics- Handbook of statistics. Ganapati P. Patil, Calyampudi Radhakrishna Rao. Elsevier Science Pub Co* *2. Coding for Beginners in easy steps: Basic programming for all ages. Mike McGrath. In Easy Steps Pub*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**2**		**3**		
CO2		**3**	**2**		**2**
CO3			**2**	**1**	
CO4	**2**	**2**			**2**
Level: 1-Low; 2-Medium; 3-High					

Elective Courses II

ENV507: Geoinformatics for Forest Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III/IV** **Year II**	
1	Course Code	**ENV507**	
2	Course Title	**Geoinformatics for Forest Management**	
3	Credits	**4**	
4	Course Status	**Elective**	
5	Course Objective	1. To impart the students in analysing and problems solving skills for forest & wildlife management using geospatial tools. 2. To train the students in practical and executable solutions to the challenges of the emergent field of Geoinformatics. 3. To the train students with a strong base of technical knowledge that makes them suitable for industries, teaching & research in Govt./public/private sector. 4. To inculcate the students towards conservation & public policy management and their responsibilities towards society.	
6	Course Outcomes **(CO)**	**CO1.**An ability to individually carry out research/developmental work to solve real-world wildlife problems and protection of forests. **CO2.** Identify explicit data and advance techniques for effective monitoring and management of forest resources. **CO3.**Design systems for decision making and work in a team using geospatial tools to achieve project objectives. **CO4.**An ability to share theoretical and practical knowledge in both teaching and learning.	
7	Course Description	The program is designed to cater to the needs of upcoming scenarios & challenges of various research and development as applicable to Government/Public /Private organizations in Geoinformatics. The program also aims to provide solutions and future trends in the areas of Forest management & climate change using Geospatial technologies.	
8	Outline syllabus		CO Mapping
	UNIT I **Forest Inventory Mapping & Monitoring**		**CO1/CO4**
	Forest inventory techniques, processes and methods, temperate and tropical forest zones, Forest resources of India, Conventional and Non-conventional forest classification in India, Sensors requirements, Geo-informatics for Forest mapping from national, regional to local level.		
	UNIT II **Forest Resources and Wildlife Management**		**CO2/CO4**

	Forest disease and damage assessment, forest Fire Identification, control and management, Forest planning, Information generation and updation through Geo-informatics, Forest resources and wildlife habitat assessment, Wildlife Management, Case Study of India and abroad, Forest recreation.			
	UNIT III **Geospatial forestry applications**			**CO3/CO4**
	Spectral characteristics of vegetation, temporal characteristics of vegetation, Vegetation indices, Forest cover density and type monitoring, mapping, assessment & management through Geospatial approach.			
	UNIT IV **Advances in Geo-informatics for forest management**			**CO4/CO4**
	Role of Thermal, Hyperspectral, Microwave and Lidar remote sensing data for forest studies and management, Forest management information system (FMIS), Forest conservation and planning.			
	Mode of Exam	**Theory + Practical**		
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
	Suggested readings:			
	1. *Anji Reddy, M. 2004: Geoinformatics for Environmental Management. B.S. Publications* 2. *Franklin S.E. 2001. Remote Sensing for Sustainable Forest Management. Lewis Publication* 3. *Gupta, R.P.., 1990: Remote Sensing Geology. Springer Verlag.* 4. *Jensen, J.R. 2000: Remote Sensing of the Environment: An Earth Resource Perspective. Prentice Hall* 5. *Lillesand, T.M., and Kieffer, R.M., 1987: Remote Sensing and Image Interpretation, John Wiley* 6. *Steven, M.D and clark, J.A., "Applications of Remote Sensing in Agriculture", Butterworths, London 1990.* 7. *Remote Sensing Applications Group, Space Applications Centre, Crop Average and production Estimation (CAPE): An Anthology from January 1986 - June 1996. (Publications in Journals, Seminars I Symposium proceedings), Ahmedabad, August 1996.* 8. *Negi, S.S., A Handbook of forestry. International Book distributors, Dehradun, 1986. Space Applications Centre, Manual of procedure for Forest mapping and Damage Detection using satellite data, Ahmedabad, 1990*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**		**2**
CO2		**2**		**2**	**3**
CO3	**1**	**3**		**1**	**3**
CO4	**3**		**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

ENV508: Occupational Hazards (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III/IV** **Year II**
1	Course Code	**ENV508**
2	Course Title	**Occupational Hazards**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. To give an understanding of the relatedness of occupations and public health and health hazards in occupations. 2. To impart knowledge on various concepts of prevention/protection to occupational Health and safety mechanisms.
6	Course Outcomes	By the end of the course, the student should be able to learn **CO1.**Relate health promotion/prevention/protection concepts to the occupational health and safety program. **CO2.** Demonstrate a base of knowledge in the recognition and assessment of types of health hazards in the workplace. **CO3.** Identify and understand the types and related safety measures of occupational health and safety. **CO4.** Recognize the interrelatedness of public health, management, employees, and the government to the goals of occupational health and safety.
7	Course Description	To develop a basic understanding of occupational health and safety

8	Outline syllabus	CO Mapping
	UNIT I **Introduction and Basics**	**CO1/CO4**
	History of concept, Recognition and evaluation of health hazards Organisational factors, Human factors.	
	UNIT II **Types of Hazards**	**CO2/CO4**
	Physical Hazards - mechanical, noise, radiation, temperature, light, structures, electrical, fire, explosion, confined space; Chemical Hazards -Vapors, mists, solids, fumes, aerosols; Biological Hazards - Fungi, molds, virus, bacteria, animals.	
	UNIT III **Occupational diseases**	**CO3/CO4**
	Pneumoconiosis, Silicosis, Anthracosis, Byssinosis, Bagasosis, Asbestosis, Farmer's lung, Metal poisoning, Occupational cancer, Occupational dermatitis, Radiation Hazards.	
	UNIT IV **Safety Management**	**CO4/CO4**

	Risk Control, Regulating health and safety, Occupational hazards in industries and other sectors, Industrial hygiene and Occupational health- Indian Scenario. Role of WHO in occupational health, Global Occupational Health Network (GOHNET)			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *S. K. Haldar, Industrial and Occupational Health, CBS Publishers & Distributors, Genre: Health and Fitness* 2. *Benjamin O. Alli, Fundamental Principles of Occupational Health and Safety* 3. *Author, International Labour Office; 2nd Revised edition edition (1 September 2008)* 4. *Barry S. Levy, David H. Wegman, Sherry L. Baron, Rosemary K. Sokas, Occupational and Environmental Health: Recognizing and Preventing Disease and Injury 6th Edition, Oxford University Press; 6 edition 2011*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**2**			**2**
CO2	**2**	**3**	**2**		
CO3	**3**	**3**			**2**
CO4	**2**		**3**	**2**	
Level: 1-Low; 2-Medium; 3-High					

ENV509: Water Resource Management (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III/IV** **Year II**	
1	Course Code	**ENV509**	
2	Course Title	**Water Resource Management**	
3	Credits	**4**	
4	Course Status	**Elective**	
5	Course Objective	1. Provide an overview of water management 2. Identify and explore the various facets of water management 3. Illustrate specific water management approaches through case histories 4. Expose students to the use and interpretation of a simple water resources model	
6	Course Outcomes **(CO)**	**CO1.** Acquire specialized concepts relevant to water resources management **CO2.** Develop an appreciation for complexities and disciplines related to water resources decision-making and policy-making **CO3.** Demonstrate the ability to obtain, analyze, synthesize, and critique information relevant to water resources in India **CO4.** Develop ethical and moral guidelines for the personal approach to water resource use and allocation issues	
7	Course Description	To address water resources management, their tools, and their limitations.	
8	Outline syllabus		CO Mapping
	UNIT I **Introduction**		**CO1/CO4**
	Main Challenges in Water Governance, Concept of Resource, The Tragedy of the Commons and the Problems of Collective Action		
	UNIT II **Integrated Water Resources Management**		**CO1/CO2**
	Multi-Sectorial Nature of Water, Concept of Integrated Water Resources Management, Beyond IWRM for the Water-Food-Energy and Ecosystem Nexus		
	UNIT III **Integrated Watershed Management**		**CO2/CO3**
	From IWRM to IWM, IWM case studies, Pollution Management, Political Challenges When Implementing Watershed Management		
	UNIT IV **Conflict and Cooperation**		**CO4**
	The emergence of International Water Law, Convention on the Protection and Use of Transboundary Watercourses, Community participation; principles of international and national laws in the area of water management; government policies at national and state level.		
	Mode of examination	Theory	

	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
	Suggested Readings	*1. Jonathan Lautze. Key Concepts in Water Resources Management; Routledge, 2014.* *2. Technical Advisory Committee, Dublin principles for water as reflected in a comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.* *3. Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.* *4. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: Global water partnership, Stockholm, Sweden. 2002.* *5. Technical Advisory Committee, Water as social and economic good: How to put the principles to practice". Technical Advisory Committee Background paper No: 2. Global water partnership, Stockholm, Sweden, 1998.*		

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**	**3**	**1**		**2**
CO2	**3**	**3**			
CO3				**3**	
CO4			**3**		**2**
Level: 1-Low; 2-Medium; 3-High					

ENV510: Aquatic and Chemical Ecology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III/IV** **Year II**
1	Course Code	**ENV510**
2	Course Title	**Aquatic and Chemical Ecology**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. Provide significant knowledge in the core domain of ecology with special emphasis on aquatic and chemical ecology 2. Provide fundamental concepts in chemical, microbial and aquatic ecology to magnify their view in the interdisciplinary linkages 3. Enable and prepare students to take an interest in the field of ecology for the advanced studies and with significantly frontier and newer areas
	Course Outcomes **(CO)**	By the end of the course the student should be able to **CO1.** Student will able to understand the concepts and characteristics of aquatic ecology and chemical ecology **CO2.** Students will be able to identify the fundamental questions in aquatic and chemical ecology with a special prospect on microbial and biotic interactions in nature **CO3.** Students will be able to improve and upgrade their knowledge in ecology and environment **CO4.** Students will be able to learn the interdisciplinary linkages in the aquatic, chemical and microbial ecology for future studies
7	Course Description	This course will be a moderate level of ecology courses. The chemical ecology component will examine how plants and animals use chemical cues to find essential resources, defend against natural enemies, locate suitable mates, and maintain social systems. Aquatic ecology will deal with all of the important aspects of significant interactions, ecological services, contamination assessment and problems of the aquatic ecology. The microbial ecology of the aquatic environment will be dealing with community structure in response to changing biogeochemistry and fundamental biochemical processes for carbon sequestration and nitrogen fixation
8	Outline syllabus	CO Mapping
	UNIT I **Chemical Ecology:**	**CO1,CO2,CO3, CO4/CO4**

	Introduction and scope of chemical ecology, the ecology of chemical defences, chemical communication, and biosynthesis of cues. Quorum sensing in bacteria, chemical signals/allelochemicals and environmental cues, chemical signals for resources and transport, pheromones, allelopathy, Examples of chemical ecology on the context of social behavior, community structure and population dynamics.			
	UNIT II **Aquatic Ecology**			**CO1,CO2,CO3, CO4/CO4**
	Distinction in ecology of fresh, brackish, estuarine and marine environments. Ecological issues related to processes and structures at different integration levels. Abiotic and biotic interactions in the aquatic bodies. Different modes of nutrition and diversity of life, ecological risk of the contaminants and risk assessment. Harmful algal blooms and stressed environment. Parental care in fishes, Coral reef dynamics.			
	UNIT III **Microbial ecology of aquatic environment**			**CO1,CO2,CO3, CO4/CO4**
	Microbiomes, Volatile Sulfur and Organic carbon emission by microbial processes. Role of autotrophic and heterotrophic bacteria in the dynamics of community structure and nutrients' assimilation. Regulation of nutrients and trace metal mobility. Advanced methods in trace metal biogeochemistry and microbial diversity			
	UNIT IV **Ecology of Aquatic Primary producers:**			**CO1,CO2,CO3, CO4/CO4**
	Ecology of phytoplankton and macrophyte, carbon sequestration and nitrogen fixation in the aquatic environment, and variability due to nutrient composition upon environmental and anthropogenic disturbances, biotic interactions e.g. algae-bacteria interactions and probable changes in the modern era of global warming and pollution			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1.*Thomas Eisner and Jerrold Meinwald, Editor- Chemical Ecology: The Chemistry of Biotic Interaction. s, for the National Academy of Sciences.* *2Anne-Geneviève Bagnères; Martine Hossaert-McKey,.Chemical ecology London, UK: ISTE Ltd ; Hoboken, NJ, USA : John Wiley & Sons, Inc., 2016.* *3. R. S. K. Barnes, K. H. Mann .Fundamentals of Aquatic Ecology.. John Wiley &Sons* *4. G. Ragothaman & R.K.Trivedy Aquatic Ecology: A Text Book.. EM International* *6. Microbial ecology: fundamentals and applications. Atlas, Ronald M; Bartha, Richard. The Benjamim. Cummings Publ., Menlo Park, 1987.* *7. Environmental Microbiology and Microbial Ecology. Barton, Larry L; MCLEAN, Robert JC. John Wiley & Sons, 2019*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**2**		
CO2	**3**	**2**	**2**		**2**
CO3	**3**	**1**	**2**	**2**	
CO4	**2**	**3**			**2**
Level: 1-Low; 2-Medium; 3-High					

ENV511: Glaciology and Climate Change (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III/IV** **Year II**
1	Course Code	**ENV511**
2	Course Title	**Glaciology and Climate Change**
3	Credits	**4**
	Course Status	**Elective**
5	Course Objective	1. Understanding of various concepts related to glaciers, characteristics features and global importance of glaciers. 2. Provide a thorough concept on methods employed for glaciological measurements. 3. Understanding of glaciological hydrology through modelling 4. Enable to comprehend the concept of climate change with special reference to the glacier as an indicator 5. Overall this course helps in-depth understanding of various glaciological related processes, features and events.
6	Course Outcomes **(CO)**	**CO1.** Concept of glaciers, its types, characteristics, and importance. **CO2.** Concept of various techniques employed for glaciological measurements **CO3.** A concept related to glacier hydrology with the help of various models. **CO4.** Knowledge of climate change through monitoring of glacier as an indicator **CO5.** Overall understanding of glacier related processes and formations.
7	Course Description	To develop a basic understanding of the glaciological process and various technical aspects related to glaciology, glacier hydrology, Climate change impact on glaciers as well as on the downstream communities.
8	Outline syllabus	
	UNIT I **Introduction**	
	Definition of glacier and types of glaciers; Process of formation of a glaciers; Snow, firn and ice; crystallization of ice; glacier distribution on the globe, the importance of glacier; Himalayan glaciers and their characteristic features, regional and global importance of glaciers	
	UNIT II **Glaciological features and Glaciological measurements**	

	Glaciological features Different zones in a glacier; Equilibrium line, accumulation area ratio and its importance; Snout, bergschrund, moulin or glacier mill, supra-glacial and sub-glacial lakes, crevasses, debris cover, glacier table; Glacial deposits; Moraines and its types; Glacier velocity; Flow of valley glaciers and concept of glacier surges **Glaciological measurements**: Definition and concept of mass balance; Methods of mass balance measurements- In-situ measurement; Remote sensing methods, Hydrological methods; Mass Balance gradients; Annual mass balance cycles, Mass balance of ice sheet			
	UNIT III **Glacier Hydrology**			
	Glacier meltwater system; Glacio-hydrological modelling- Purposes and types; Glacier mass balance model, energy balance model, Temperature index models; Discharge measurement method, diurnal and seasonal variation			
	UNIT IV **Climate Change and Glaciers**			
	Glacier as an indicator of climate change; Impacts of Climate Change on Cryosphere; Impacts of climate change on the glacier, permafrost and glacial lake; Impacts of climate change hydrology of glacierized river basin; Impacts on water resources of India, Socio-economic impacts. Glacial hazards and concept of GLOF			
	Mode of examination	Theory		
	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of-Semester examination
		20%	20%	60%
	Text book/s*	Ware, George M.(Ed) (2007) Reviews of environmental contamination and toxicology. Vol. 190: Continuation of residue reviews, Springer Publishers		
	Other References	1. *Physics of glacier, Fourth edition, 2011, Kurt M. Cuffey, W. S. B. Paterson, Elsevier.* 2. *Fundamentals of Glacier Dynamics, Second edition, 2013, C.J. Van der Veen, CRC press, Taylor & Francis Group,* 3. *Glaciers and Glaciation, 2010, 2nd edition Douglas Benn and David J A Evans, Hodder Arnold Publication*		

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**2**	**3**			
CO2	**3**	**2**	**3**		**2**
CO3	**2**	**3**	**3**	**1**	
CO4	**2**	**2**			**3**
CO5		**3**	**2**		
Level: 1-Low; 2-Medium; 3-High					

ENV512: Environmental Stress on Vegetation (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**	
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21**	
		SEMESTER III/IV **Year II**	
1	Course Code	**ENV512**	
2	Course Title	**Environmental Stress on Vegetation**	
3	Credits	**4**	
4	Course Status	**Elective**	
5	Course Objective	1. To understand the various environmental stresses and effects on plants. 2. To learn the effect of environmental stresses as limiting factors in plant growth, development, productivity, and plant biodiversity.	
6	Course Outcomes **(CO)**	**CO1**.Students would be able to correlate environment stress generation and their effects on the plants. **CO2.** The students will understand physiological and biochemical mechanisms in plants altered due to environmental stress **CO3** Understanding plant adaptive measures under stress. **CO4.** Utilization of knowledge for bio-indicating mechanism under environmental stresses, and adaptive mechanism.	
7	Course Description	To impart the latest development about biochemistry and physiology of biotic and abiotic stresses in plants	
8	Outline syllabus		CO Mapping
	UNIT I **Environmental Stress**		**CO1/CO4**
	Natural and anthropogenic generation of environmental stresses, Abiotic:- radiation, salinity, floods, drought, extremes in temperature, heavy metals, environmental pollution; Biotic stresses- pathogens fungi, bacteria, oomycetes, nematodes and herbivores		
	UNIT II **Physiological and Biochemical Mechanisms in vegetation**		**CO2/CO4**
	Plant physiology-electron transport system, Photosynthesis:C3, C4 pathways, photorespiration; Nitrogen metabolism; Biochemistry of altered membrane permeability; Free radical formation; Lipid peroxidation; Antioxidative defence mechanism; Signalling pathways due to ROS production under biotic and abiotic stress		
	UNIT III **Environmental Stress: Plant Adaptation**		**CO3/CO4**
	Biotic and abiotic stresses affect plant growth, development and crop productivity; Adaptation strategies at the morphological and anatomical level of plants; Signal transduction; Phytohormones.		
	UNIT IV		**CO4/CO4**

	Environmental stress: Bioindicator system			
	Plants responses to climate change and environmental stress; Bio-indicating approach for environmental stress identification; Changes in vegetation; Effect on biodiversity; plant's adaptive mechanism against environmental stresses			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Lincoln Taiz and Eduardo Zeiger, Plant Physiology, 5th Edition, 2012* 2. *Bob B. Buchanan and Wilhelm Gruissem, Russell L. Jones (Eds), Biochemistry and Molecular Biology of Plants, 2nd Edition, 2015* 3. *Cherry, Joe H. (Ed.), Environmental Stress in Plants, Biochemical and Physiological Mechanisms, 1989* 4. *Fowden, L., Mansfield, T., Stoddart, J. (Eds.), Plant Adaptation to Environmental Stress, 1993* 5. *Dey PM & Harborne JB. 1997. Plant Biochemistry. Academic Press, 1997*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**3**		**2**		
CO2	**2**	**3**			**2**
CO3			**2**	**2**	
CO4	**2**	**3**			**3**
Level: 1-Low; 2-Medium; 3-High					

ENV513: Carbon Capture and Sequestration Technology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-21**
Program: M.Sc. Environmental Science		**Current Academic Year: 2020-21** **SEMESTER III/IV** **Year II**
1	Course Code	**ENV513**
2	Course Title	**Carbon Capture and Sequestration Technology**
3	Credits	**4**
4	Course Status	**Elective**
5	Course Objective	1. Understanding the carbon concentrating mechanisms and global carbon cycling in the context of climate change mitigation and the significance of carbon capture technologies 2. Giving exposure to current and future CCS technologies with their merits and demerits 3. Provide a basic foundation of knowledge on the implication of the low carbon technologies and integration of CCS technologies for food, energy and environment
6	Course Outcomes **(CO)**	By the end of the course, the student should be able to **CO1.** Students will understand how carbon is regulated in different environmental components and how carbon capture and sequestration/storage (CCS) fits into the energy space **CO2.** Students will be able to judge the appropriate methods of carbon capture and sequestration **CO3.** Students will be able to understand the biological carbon capture and sequestration procedures and carbon concentrating mechanisms in the biological world. **CO4.** Students will be able to develop a sound understanding to opt for higher studies on the low carbon technologies and integration of CCS technologies for food, energy and environment.
7	Course Description	The course is distributed in 4 different units. The first unit is an overall introduction to how carbon is regulated in different environmental segments and how carbon capture and sequestration/storage (CCS) fit into the energy space. It will cover carbon emission and the question of how long we will rely on fossil energy. Unit 2 and 3 are on chemical and physical methods of carbon capture and sequestration including geological carbon sequestration. Unit 4 gives some alternatives for geological and soil-based carbon sequestration through biological routes (using microbes, plants, biomolecules, and carbon concentrating mechanisms).
8	Outline syllabus	CO Mapping
	UNIT I **Introduction and scope of the CCS and its linkages**	**CO1,CO2,CO3/CO3**

	Introduction and scope of the CCS. CCS in the energy space- A nexus between energy, electricity, fossil fuel and carbon emission, Carbon budget of the Earth, Carbon emissions and sequestration in different environmental segments, atmospheric, trends of historic CO2 levels and global changes in carbon, limitations of the natural carbon sequestration.			
	UNIT II **Chemical and Physical methods of Carbon sequestration**			**CO1, CO3/CO3**
	Different physical and chemical technologies of carbon capture, storage and sequestration. Absorption- existing agents and technologies, selection of absorbing agents, optimizing on absorption process, Adsorption- Selection of adsorbent, Novel materials for adsorption. Membranes- physical and chemical factors affecting the potential membranes for carbon sorption and transformation. Artificial photosynthesis. Merits and demerits of the different methods			
	UNIT III **Geotechnology for CCS**			**CO1, CO3/CO3**
	Geologic Carbon Sequestration: Introduction, Continuum Scale, Pore-Scale Phenomena, selection of CO2 storage sites, additional economical processes e.g enhanced oil recovery, Carbon sequestration using deep natural minerals, saline lands, lagoons, the process of CO_2 injection and transportation, sorption and sequestration mechanisms. CO2 sequestration in seawater and saline reservoirs. Carbon sequestration in soil.			
	UNIT IV **Biological Carbon sequestration and integrated technologies**			**CO1,CO2,CO3/CO3**
	Strategies of preservation and enhancement of terrestrial and aquatic carbon sinks, Carbon sequestration using microbes, plants and biomolecules, Bioconversion of CO_2, RUBISCO and Carbon concentrating mechanisms (CCM) in plants and algae, limitations of CCM, cell physiology of linking CO_2 and energy biomolecules, Bio-refinery and carbon-neutral fuel, integrated low carbon technologies, flue gas carbon capture using algae and carbon credits.			
9	Mode of examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Baird, C., and Cann, M., Environmental Chemistry, W.H. Freeman and Company, 2008.* 2. *Manahan, S. Environmental chemistry. CRC press, 2017.* 3. *Rackley, S. A. Carbon Capture and Storage, Second edition Butterworth-Heinemann –Elsevier. 2017* 4. *Wilcox and Jennifer, Carbon Capture, Springer, 2012* 5. *Hester RE, Harrison RM, editors. Carbon capture: sequestration and storage. Royal Society of Chemistry; 2010.* 6. *Borowitzka, M.A., Beardall, J. and Raven, J.A. eds., 2016. The physiology of microalgae (Vol. Cham: Springer.*			

CO-PO Compliance Matrix	PO1	PO2	PO3	PO4	PO5
CO1	3	2			
CO2	2	3	2		3
CO3	3	2		1	
CO4	2	3			3
Level: 1-Low; 2-Medium; 3-High					

Ph.D. Environmental Science

Central University of Rajasthan
School of Earth Sciences
Department of Environmental Science
Ph.D. in Environmental Science
SYLLABUS

ENV701: Research Methodology (4 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**	
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**	
1	Course Code	**ENV701**	
2	Course Title	**Research Methodology**	
3	Credits	**4**	
4	Course Status	**Core**	
5	Course Objective	1. To develop an understanding of the basic framework of the research process 2. The course aims to augment the aptitude of research among students 3. To facilitate the students in understanding the tools and techniques of conducting thesis 4. To develop an understanding good laboratory practice.	
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Work on the identification of research questions, review the research literature. **CO2.** Identify different ways to collect and analyse qualitative and quantitative data **CO3.** Develop a good research proposal and further completion of thesis and research publications **CO4.** Understanding of good laboratory practices	
7	Course Description	Skills and knowledge related to research methodologies, data interpretation, and laboratory practices	
8	Outline syllabus		CO Mapping
	UNIT I **Research Basics**		**CO1/CO4**
	Research Basics: definition, purpose and types; Significance of research in applied sciences; Process of Research; Objectives and Dimensions of Research problem, Research questions, Research design; Tools of Research: Library, Field, Laboratory; Methods of research: Qualitative and Quantitative; Systematic review of literature in applied sciences; Critical literature survey- Science Indexes e.g. SCOPUS, Web of Science, Science Direct, Del Net.		
	UNIT II **Statistical Techniques**		**CO2/CO4**

<table>
<tr><td></td><td colspan="4">Research Basics; Data Types (primary and secondary data), collection methods; presentation (Graphical and diagrammatical); relevance, limitations, and cautions. Data Processing: checking, editing, coding, transcriptions, classification, and tabulation; Data analysis: meaning and methods; quantitative and qualitative analysis; Bivariate Data Analysis using Correlation and Regression analysis Analysis of time series, Interpolation, and Extrapolation; Statistical fallacies: Bias, Faulty generalization, inappropriate comparison, misuse of various tools like mean, median, mode, dispersion, correlation, technical errors; Theoretical distribution: Normal, Poisson, Binomial with application in various area/ disciplines; Sampling: types, steps; sampling errors, sampling of attributes (including Chi-square test), sampling of small and large sample variables (including ANOVA); Hypothesis Testing.</td></tr>
<tr><td></td><td colspan="3">UNIT III
Data Analysis in Environmental Studies</td><td>CO3/CO4</td></tr>
<tr><td></td><td colspan="4">Environmental sampling: Finite-population sampling, stratified random sampling, composite sampling, ranked set sampling, capture-recapture methods; Time series analysis: Trend estimation, autocorrelation function, autoregressive models, forecasting methods; Spatial statistics: Interpolation techniques, autocorrelation, Introduction of statistical packages: Calculation of various statistical parameters, tests, temporal and spatial data analysis, preparation of charts; Interpretation of statistical outputs in reports andpapers.</td></tr>
<tr><td></td><td colspan="3">UNIT IV
Good Laboratory Practices</td><td>CO4/CO4</td></tr>
<tr><td></td><td colspan="4">Setting up experiment, laboratory safety measures, disposal of Hazardous/Poisonous/chemical and biological agent, laboratory waste disposal, Dealing with electrical and fire hazards</td></tr>
<tr><td>9</td><td>Mode of Examination</td><td colspan="3">Theory</td></tr>
<tr><td rowspan="2">10</td><td rowspan="2">Weightage Distribution</td><td>Internal Assessment-I</td><td>Internal Assessment-II</td><td>End of Semester Examination</td></tr>
<tr><td>20%</td><td>20%</td><td>60%</td></tr>
<tr><td>11</td><td colspan="4">Suggested readings</td></tr>
<tr><td></td><td colspan="4">

Jay L Devore: Probability and Statistics for Engineering and the Sciences: CENAGAGE, Learning. Print in India.
Rice, J.A. (2007): Mathematical Statistics and Data Analysis: CENAGAGE Learning Pvt. Ltd.
Spiegel M.R. and Stephens J.L. (2010) Statistics, Tata McGraw Hill.
Das N.G. (2011): Statistical Methods, Tata McGraw Hill.
Bernard A. Rosner (2011), Fundamentals of Biostatistics, 7th Ed., Cenagage Learning Pvt. Ltd.
L.W.Neuman.1997. Social Research Methods: Quantitative and Qualitative approaches. Allyn& Bacon. 560 pp6.
Vinay Kumar Srivastava. 2004. (ed) Methodology and Fieldwork, Oxford University Press, New Delhi
Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS
Publishers'Distributors
Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi,
Wiley Eastern Limited.
Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners (2nd Edition), Pearson Education.
Kendra Cherry: Introduction to Research Methods : available for download at http://psychology.about.com/od/researchmethods/ss/expdesintro.htm
Davis S. Walonick: Elements of a research proposal and report: available for

</td></tr>
</table>

	download at http://www.statpac.com/research-papers/research-proposal.htm

CO-PO Compliance Matrix	PO1	PO2	PO3
CO1	**3**	**2**	**2**
CO2	**1**	**2**	**2**
CO3	**1**	**3**	**3**
CO4	**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV702: Research and Publication Ethics (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**	
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**	
1	Course Code	**ENV702**	
2	Course Title	**Research and Publication Ethics**	
3	Credits	**3**	
4	Course Status	**Core**	
5	Course Objective	1. To make students aware of research ethics. 2. To introduce students to research synopsis, proposal, and findings.	
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Develop an understanding of the research ethics and scientific conduct. **CO2.** Develop thesis structure, documentation and publication ethics. **CO3**. Develop research synopsis, proposal and research funding. **CO4.** Develop Research Practice	
7	Course Description	To develop an understanding of the ethical dimensions of conducting applied research and publication. As per the UGC guideline, **D.O.No.F-1-1/2018(Journal/CARE), December, 2019**.	
8	Outline syllabus		CO Mapping
	UNIT I **Philosophy of Ethics and Scientific Conduct**		**CO1/CO4**
	Introduction to philosophy, Science and ethics: science as the social, cultural and human pursuit.; Ethical theory and applications; Research ethics: (Issues relating to referencing and documentation, copyrights, patents, plagiarism, and intellectual property right), Impact Factor, H-Index, Citation Index, references/ bibliography. Intellectual honesty and research integrity; Scientific misconduct; Redundant publications; Selective reporting and misrepresentation of data.		
	UNIT II **Thesis structure, documentation and Publication ethics**		**CO2/CO4**
	Structuring the Ph.D. Thesis: chapter format, identification, using quotations, footnotes, abbreviations, presentation of tables and figures, referencing, documentation, use and format of appendices, indexing, Systematic review of literature; Features of a research study. Publication ethics; conflict of interest; publication misconduct; violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals; predatory publishers and journals.		
	UNIT III **Research synopsis, proposals, and fundings**		**CO3/CO4**
	Preparation of Research Plan/Synopsis, writing of research papers, research report, Organization of seminars, symposiums, conferences, and workshops; General idea about fellowships and funding agencies.		
	UNIT IV **Research Practice**		**CO4/CO4**

	Open access publishing: Open access publications and initiatives; online research to check publisher copyright & self-archiving policies; software tool to identify predatory publications; Journal finder/ suggestions tools; Publication misconduct: Group discussion, software tools; Data base and Research metrices: Indexing databases, citation databases, impact factor of journals as per the journal citation report, cite score.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. Bird, A. (2006). Philosophy of Science. Routledge. *2. MacIntyre, Alasdair (1967) A short History of Ethics. London.* *3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get Plagiarized.* *4. National Academy of Science, National Academy of Engineering and Institute of Medicine (2009). On being a Scientist: A guide to Responsible Conduct in Research, Third Edition, National Academic Press.* *5. Indian National Science Academy (INSA),2019. Ethics in Science, Education, Research, and Governanace.* *6. David B. Resnik, 1998, The Ethics of science: An introduction. Routledge publisher, USA.* *7. D Callahan $ S Bok, 1996, Ethics Teaching in Higher Education. Plenum Press, New York,USA.* *8. J N Kapur, 1996, Ethical Values for Ecellence in Education and Science. Wishwa Prakashan, New Delhi.* *9. A N Tripathi, 2008, Human values. New Age international Publishers, New Delhi.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**3**
CO2	**2**	**3**	**3**
CO3	**3**	**2**	**2**
CO4	**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV703: Research Review Writing and Seminar (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**		
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**		
1	Course Code	**ENV703**		
2	Course Title	**Research Review Writing and Seminar**		
3	Credits	**3**		
4	Course Status	**Elective**		
5	Course Objective	1. To make students aware of research review writing. 2. To make students to present research review in seminar		
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Develop an understanding of the fundamentals of research review writing **CO2.** Develop research reading, writing, and presentation.		
7	Course Description	This course provides an advanced understanding of research reading, writing and presentation.		
8	Outline syllabus			CO Mapping
	Course should be undertake under the supervision of concerned supervisor in the related research area. student will review the relevant and latest research, review scientific reports to prepare review writeup. Research review should be presented and evaluated by the concern supervisor and evaluation committee by departmental seminar.			**CO1 and CO2**
9	Mode of Examination	Review writeup and Presentation		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**3**
CO2	**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV704: Advance Analytical Techniques (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**		
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**		
1	Course Code	**ENV704**		
2	Course Title	**Advance Analytical Techniques**		
3	Credits	**3**		
4	Course Status	**Elective**		
5	Course Objective	3. To make students aware of advance/emerging technologies used for environmental pollution monitoring and their control. 4. To introduce students to the current trends of sampling and modern analysis relevant to environmental sciences.		
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Critically evaluate and interpret experimental data and findings. **CO2.** Undertake the correct sample preparation and characterization prior to analysis by the chosen techniques or instruments. **CO3**. Process data from the complex instruments and demonstrate an understanding of the limitations and quality of the data. Justify the approach taken to data processing.		
7	Course Description	This course provides an advanced understanding of analytical techniques along with data quality.		
8	Outline syllabus			CO Mapping
	UNIT I **Introduction**			**CO1/CO2**
	Analytical tools in environmental science- sampling techniques and extraction processes			
	UNIT II **Fundamental Techniques**			**CO1/CO3**
	Principles and applications of Electro-analytical techniques, Separation Methods, Qualitative Optical Spectroscopic methods, Quantitative Optical Spectroscopic methods			
	UNIT III **Hyphenated Techniques and emerging applications**			**CO1/CO3**
	Mass Spectrometry (MS), Hyphenated techniques, Microscopic and surface analysis, Emerging technologies for environmental monitoring and pollution control			
	UNIT IV **Geospatial approach**			**CO2/CO3**
	Current trends of Remote Sensing and GIS applications in Environmental Science			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination

		20%	20%	60%
11	Suggested readings			
	1. *Skoog, D.A., Holler, F., Crouch, S.R., Instrumental Analysis, Cenage Learning India Pvt. Ltd, New Delhi, 2007* 2. *Settle, F. Instrumental Techniques for Analytical Chemistry, Prentice-Hall, Inc., Englewood Cliffs, NJ, (1997).* 3. *Popek, E. P. Sampling and analysis of environmental pollutants: a complete guide, USA: Academic (2003).* 4. *Lillesand, T., Kiefer, R. W., & Chipman, J. Remote sensing and image interpretation. John Wiley & Sons, (2014).*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**2**	**3**	**1**
CO2	**3**	**2**	**3**
CO3	**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV705: Water Resources and Climate Change (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**		
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**		
1	Course Code	**ENV705**		
2	Course Title	**Water Resources and Climate Change**		
3	Credits	**3**		
4	Course Status	**Elective**		
5	Course Objective	1. The aim of the course is to develop linkage between climate change and water resources, including understanding, modelling and projection of hydrological processes at river basin scale. 2. To develop capability of various tools and techniques to use climate data and various processing methods.		
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** Demonstrate an understanding of linkages between climate and water resources **CO2.** Set hydrological model for studying the impacts of climate change on water resources and hydrological processes		
7	Course Description	This course provides an advance understanding of analytical techniques along with data quality.		
8	Outline syllabus			CO Mapping
	UNIT I **Introduction**			**CO1**
	Elements of a watershed, hydrological cycle, hydro-meteorological variables and measurement; Elements of a watershed, hydrological cycle, hydro-meteorological variables and measurement.			
	UNIT II **Models**			**CO1/CO2**
	Rainfall-runoff modelling, land capability classification, use of remote sensing and GIS tools in database preparation, hydrological models- calibration and validation, application of rainfall-runoff model.			
	UNIT III **Impacts**			**CO1/CO2**
	Interlinking surface-groundwater, impact of landuse/landcover change on surface and groundwater resources, impact of climate change and water resources			
	UNIT IV **Scenarios and corrections**			**CO1/CO2**
	Regional and global climate models and scenarios, bias-correction techniques, spatial and temporal downscaling, uncertainty in hydrologic projections, hydro-climatic extremes			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination

		20%	20%	60%
11	Suggested readings			
	1. *Burrough, P.A. and McDonnell, R.A. (1998) Principles of geographical information systems, Oxford University Press, Oxford, 327 pp.* 2. *Chow, V.T 1988, Applied Hydrology, Tata McGraw Hill Publishing Co.Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (2005) Geographic* 3. *Information Systems and Science. Chichester: Wiley. 2nd edition.* 4. *Subramanya, K 2004, Engineering Hydrology, Tata McGraw-Hill, New Delhi.* 5. *Saeid Eslamian, Handbook of Engineering Hydrology: Modeling, Climate Change, and Variability*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**2**	**3**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV706: Air Pollution, Monitoring, Control and Effects (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**	
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**	
1	Course Code	**ENV706**	
2	Course Title	**Air Pollution, Monitoring, Control and Effects**	
3	Credits	**3**	
4	Course Status	**Elective**	
5	Course Objective	1. To introduce major pollutants, present in air and sources 2. To provide knowledge of various sampling methodologies and pollution control technologies 3. Interaction of air pollution with atmospheric and meteorological variations. 4. To assess the effect of air pollution on plants and humans	
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** Students should able to learn about the effect of atmosphere and anthropogenic sources in air pollution **CO2.** Understand the basic theory and application of pollution monitoring and control devices. **CO3.** Understanding of atmospheric interaction with air pollutants causing the effect on formation and dispersion. **CO4.** Understanding the effect of air pollutants inducing stress on plant's growth, development, and Productivity and Plant bio-indicating measures. Also understanding effects on human's health	
7	Course Description	Skills and knowledge related to air pollution, sources, interaction with atmospheric variations, and effects on plants and humans.	
8	Outline syllabus		CO Mapping
	UNIT I **Air Pollutants: Types and Sources**		**CO1/CO4**
	Concepts of air pollution and sources, Primary and secondary air pollutants, Inorganic and organic air pollutants, aerosols, particulate matters; Future trends for urban pollution in developed and developing countries.		
	UNIT II **Monitoring and Control**		**CO2/CO4**
	Recent technologies for air sampling and analysis of persistent organic pollutants, Organic Carbon and Black carbon analysis, dose-response analysis, Air pollution control technologies-Settling chamber, cyclone separator, fabric filter, electrostatic precipitators; wet collector (scrubber); Methods of control of gaseous pollutants-condensation, absorption, adsorption, combustion and biological control systems, green belt, green bench, and carbon credits.		
	UNIT III **Atmospheric interaction with air pollution**		**CO3/CO4**

	Atmospheric dispersion and modelling, plume behaviour, Forces affecting vertical and horizontal movement of air, global and local circulation of air, microclimate, wind profiles, topographic effects; Meteorological factors affecting air pollution formation and dispersion, the stability of atmosphere using temperature profile, inversions, plume behaviour and calculation of plume rise, turbulent diffusion.			
	UNIT IV **Effect of air pollution on plants and humans**			**CO4/CO4**
	ROS production under air pollutants induced stress; Physiological and biochemical effects on plants, Effect on plant's growth, development and productivity; Adaptation strategies of plants under stress; Bio-indicating approach for air pollution identification. Health risk assessment, carcinogenic potencies, toxic equivalent factors (TEFs).			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.* 2. *Davis, M.L. and Cornwell, D.A. Introduction to Environmental Engineering. WCB/McGraw-Hill Publications.* 3. *Nevers, Noel De, Air Pollution Control Engineering, McGraw-Hill International Editions, 2000.* 4. *Ray, T.K. Air Pollution Control in Industries. Tech Books International, New Delhi.* 5. *Vallero, Daniel A. Fundamental of Air Pollution, Fourth Edition, Academic Press.* 6. *Lincoln Taiz and Eduardo Zeiger, Plant Physiology, 5th Edition, 2012* 7. *De Nevers, N., Air Pollution Control Engineering, 3rd edition Waveland Press Inc 2016.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**2**	**3**	**2**
CO3	**2**	**2**	**3**
CO4	**3**	**2**	**2**
Level: 1-Low; 2-Medium; 3-High			

ENV707: Environmental Biotechnology (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**
1	Course Code	**ENV707**
2	Course Title	**Environmental Biotechnology**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	1. To impart knowledge about applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments/ industrial effluents. 2. To understand various optimization techniques for biochemical engineering of culture experiments. 3. Understand the principles of bioremediation of synthetic organic pollutants, heavy metals and basic physiology of a microorganism during bioremediation and bio-refinery studies. 4. To understand the microbial physiology and enzyme kinetics for biodegradation and bio-refinery studies.
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** The student should be able to understand the basic principles of the microbiology of environmental engineering systems for the treatment of various organic wastes. **CO2.** The student should be able to recognize and apply environmental biotechnology approaches in the treatment and disposal of organic wastes, production of biomaterials /integrated bio-refinery/ biofuels and pollution control through optimization techniques. **CO3.** Students will be able to understand the extremophiles and biosynthesis of fuel precursors & pigments. **CO4.** Students will gain a significant understanding of various stress coping mechanisms and strategies in response to heavy metal/ lanthanide exposure in addition to advanced bioremediation technologies.
7	Course Description	This course is designed to fulfil skills and knowledge related to the environmental biotechnology of heavy metal, lanthanide and POP's remediation and integrated bio-refinery (biofuel, enzymes, and pigments)
8	Outline syllabus	CO Mapping
	UNIT I **Environmental Biotechnology for Waste management**	**CO1/CO4**
	Introduction, the role of biotechnology in environment management, industrial waste management, advanced wastewater treatment, hazardous waste management, biomedical waste management, oil spill, PCBs, PAH, dioxins	
	UNIT II	**CO2/CO4**

	Bioprocess Engineering, Applications and Monitoring			
	Bioprocess engineering, optimization software, enzyme kinetics, purification, kinetics, applications, metagenomics, degradation of xenobiotics, environmental toxicity, assays, Photobioreactors/bioreactors			
	UNIT III **Physiology of valuable products and Extremophiles**			**CO3/CO4**
	Biofuel and pigment production using algae and bacteria. Biosynthetic routes of pigments and fuel precursors (fatty acids/lipids, carbohydrate, etc). Extremophiles and applications			
	UNIT IV **Physiology of heavy metals and Bioremediation**			**CO4/CO4**
	Lanthanide and heavy metal avoidance, tolerance and accumulation in microbes and macrophytes; and advanced bioremediation technologies.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	Suggested Readings 1. *Biochemical Engineering fundamentals, 2nd ed. By J E Bailey and D F Ollis, McGraw Hill, 1986.* 2. *Bioprocess Engineering Principles by Pauline M. Doran, Academic Press* 3. *Environmental Biotechnology by Indu Shekhar Thakur., IK International Pvt. Ltd.* 4. *Fundamentals of Enzymology by Nicholas C. Price & Lewis Stevens, 3rd edition, Oxford University press, New York.* 5. *Industrial Microbiology by CASIDA* 6. *Introduction to Bio-deterioration by D. Allsopp and K.J. Seal. ELBS/Edward Arnold.* 7. *Algae for Biofuels and Energy by Borowitzka, Michael A., Moheimani, Navid Reza. Springer Netherland. Springer Netherlands.DOI: 10.1007/978-94-007-5479-9*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**2**	**3**	**2**
CO3	**2**	**2**	**3**
CO4	**2**	**3**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV708: Nanotechnology: Environmental Applications (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**
1	Course Code	**ENV708**
2	Course Title	**Nanotechnology: Environmental Applications**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	5. Equip the students with the basic concepts and principles of nanoscience and nanotechnology 6. Provide a basic understanding of nanomaterial synthesis approaches and methods 7. Explain the theoretical basis of the techniques required for characterization of nanomaterials 8. Develop an understanding of varied applications of nanotechnology in the area of environmental remediation.
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Acquire knowledge relating to the fundamentals in the area of nanoscience & nanotechnology and understand the discipline's relevancy to human society **CO2.** Gain familiarity with different methods of nanomaterial synthesis **CO3**. Explain the suitability of characterization technique for identification of varied nano-related properties **CO4.** Apply fundamental concepts of nanotechnology to the problems of environmental pollution
7	Course Description	This course provides an overview of nanoscience including synthesis, characterization and properties of nanomaterials along with their application in the field of environmental cleanup.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1/CO4**
	Nanoscience and Nanotechnology; Basics and scale of nanotechnology; History of nanotechnology; Nanoscale material classification; Properties of nanoparticles	
	UNIT II **Synthesis Methods**	**CO2/CO4**
	Introduction to 'Top-down' vs. 'Bottom-up' approach of synthesis; Physical, Chemical and Biological methods of nanomaterial synthesis; Pro and cons of synthesis methods	
	UNIT III **Characterization Techniques**	**CO3/CO4**
	Basic understanding of multiple techniques with special emphasis on characterization at nano scale - X-ray diffraction analysis; Fourier transform infrared spectroscopy; Raman spectroscopy; X-ray photoelectron spectroscopy; Transmission electron microscopy; Scanning electron microscopy; Atomic force microscopy; Vibrating sample magnetometry; Thermal gravimetric analysis.	

	UNIT IV **Environmental Application**			**CO4/CO4**
	Role of nanoparticles in environmental clean-up; Application of nanomaterial for wastewater treatment, water disinfection, contaminated groundwater/ surface water and soil/sludge/sediment treatment; Remediation mechanisms; Potential risks, public health & environmental concerns; Case studies.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Sellers K., Mackay C., Bergeson L.L., Clough S.R., Hoyt M., Chen J., Henry K., Hamblen J. Nano-technology and the environment, CRC Press, Taylor and Francis Group.* 2. *Shong C.W., Haur S.C., Wee A.T.S. Science at the Nanoscale - An Introductory Text Book, PAN Stanford Publishing.* 3. *Kane D.M., Micolich A., Roger P. Nanomaterials: Science and Applications. Pan Stanford, 2016.* 4. *Krishnamoorthy S. Nanomaterials: A Guide to Fabrication and Applications. CRC Press, 2015.* 5. *Haghi A.K., Zachariah A.K. and Kalariakkal N. Nanomaterials: Synthesis, Characterization and Applications. Apple Academic Press. 2013.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**2**	**3**	**2**
CO3	**2**	**3**	**2**
CO4	**1**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV709: Geospatial Technology for Environmental Management (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**
1	Course Code	**ENV709**
2	Course Title	**Geospatial Technology for Environmental Management**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	1. To expose students to applications of GIS and remote sensing in environmental management 2. To develop a sound basis for understanding the operation of GIS and Remote Sensing in environmental management. 3. To understanding the role played by technical experts, stakeholders and decision-makers 4. To demonstrate case studies of selected areas using GIS softwares.
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Acquire knowledge relating to the fundamentals in the area of Environmental Management and understand the discipline's relevancy to society **CO2.** Gain familiarity with different methods of Environmental monitoring and Management using geospatial tools. **CO3**. Explain the suitability of Geospatial technique for Environmental problems and sustainable management. **CO4.** Apply fundamental concepts of different ecosystems functioning with latest technological tools.
7	Course Description	This course provides an overview of Environmental Management with geospatial (Remote Sensing, GIS and GPS) tools with emphasis to environmental problems and their management.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1/CO4**
	Environment & ecosystems, functions and types of ecosystems, ecosystem model concept, types of models of Ecosystems & Environmental applications.	
	UNIT II **Environmental Resources**	**CO2/CO4**
	Air, water and land resources, forest resources, forest biomass, forest inventory, types of sample plots, volume estimation, uncertainty in forest biomass estimation.	
	UNIT III **Environmental RS & GIS Techniques**	**CO3/CO4**
	Fundamentals of geospatial (Remote Sensing, GIS and GPS) technology: definition, advantages, limitations, concept and principles, environmental resource satellite sensors, classification methods, advances with Hyperspectral, RADAR & LIDAR	
	UNIT IV **Environmental Management Applications**	**CO4/CO4**

	Geospatial based applications in environmental management, multilevel remote sensing and ground data to estimate forest biomass, advance tools in RS & GIS for assessment of biomass, carbon pool and flux assessment, carbon sequestration and impacts on climate change, environmental concerns: Case studies.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Baretl, E.C. and Culis I.F. Introduction to Environmental Remote Sensing, second edition, Chapman and Hall, New York, 1993.* 2. *Lintz, J. and Simonent, D.S. Remote Sensing of environment Addision Wesley, Rading mars, 1976.* 3. *Jorgensen, Sven Erik. Handbook of environmental and ecological modeling. CRC Press. pp. 403–404. 1996.* 4. *Grant, William Edward & Swannack, Todd M. Ecological modeling: a common-sense approach to theory and practice. John Wiley & Sons. p. 74. 2008.* 5. *Hall, Charles A.S. & Day, John W. Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories. University Press of Colorado. p. 9. 1990.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**2**	**3**	**2**
CO3	**2**	**3**	**3**
CO4	**1**	**3**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV710: Biogeochemistry (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**
1	Course Code	**ENV710**
2	Course Title	**Biogeochemistry**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	1. To investigate Biogeochemical cycles (C, N, P, S, and metals), the microorganisms and the chemical reactions that take place during these cycles. 2. To understand the environments in which biogeochemical processes occur (e.g., hydrosphere, lithosphere, and atmosphere) specifically wetlands, oceans, estuaries, soils, and sediments. 3. To understand the various methodologies used to measure Biogeochemical processes.
6	Course Outcomes **(CO)**	The student should be able to: **CO1.** Explain the evolution of biogeochemical systems on the Earth, and interactions among the various "spheres". **CO2.** Explain the fundamental biogeochemical principles that occur at local, regional, and global scales. **CO3.** Describe and understand the various techniques used in biogeochemistry and how these techniques can be coupled with the scientific method to address questions related to human impacts and global change on Earth. **CO4.** Develop an understanding to write a publishable synthesis paper on a biogeochemical topic of interest to the student.
7	Course Description	This course allows the student to learn key concepts and major topics in biogeochemistry and also to understand the fundamentals of the methods used in biogeochemical research.
8	Outline syllabus	CO Mapping
	UNIT I **Introduction**	**CO1**
	Earth as a biogeochemical system, Origins of the Elements, Evolution of Metabolic Pathways	
	UNIT II **Biogeochemical spheres**	**CO1/CO2**
	Biogeochemical reactions in the atmosphere, lithosphere, hydrosphere and biosphere, biogeochemical cycling of macro elements, biogeochemical cycling of trace elements, interactions of biogeochemical cycles	
	UNIT III **Ecosystem Biogeochemistry**	**CO2/CO3**
	Wetland ecosystem- Productivity, Organic Matter Storage, Microbial Metabolism, Wetlands and Water Quality; Inland waters- Carbon and Nutrient cycling in lakes, rivers and estuaries; Oceans-	

	Sediment Diagenesis, The Biological Pump: A Model of Carbon Cycling in the Ocean, Nutrient Cycling in the Ocean, Sedimentary Record of Biogeochemistry			
	UNIT IV **Global context**			**CO3/CO4**
	*Advances in biogeochemistry, s*table isotopes in biogeochemistry and their application to various environmental problems, Human impacts on global biogeochemistry.			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *William H. Schlesinger, Biogeochemistry, Elsevier. 2005.* 2. *Thomas S. Bianchi, Biogeochemistry of Estuaries; Oxford University Press. 2009.* 3. *Kenneth D. Black and Graham Shimmield, Biogeochemistry of Marine Systems; CRC Press. 2003.* 4. *Fengxiang X. Han, Arieh Singer, Biogeochemistry of Trace Elements in the Arid environments; Springer. 2007.* 5. *K. Ramesh Reddy, Ronald D. DeLaune. Biogeochemistry of Wetlands; CRC Press. 2008.* 6. *William H. Schlesinger and Emily S. Bernhardt, Biogeochemistry- An analysis of global change; Academic Press. 2013*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**3**	**2**	**1**
CO3	**2**	**3**	**2**
CO4	**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			

ENV711: Advances in Glaciology (3 Credits)

School: School of Earth Sciences		**Batch: 2020-2021**
Program: Ph.D. Environmental Science		**Current Academic Year: 2020-2021**
1	Course Code	**ENV711**
2	Course Title	**Advances in Glaciology**
3	Credits	**3**
4	Course Status	**Elective**
5	Course Objective	6. Conceptualization of glaciers, and its global importance. 7. Understanding of glaciological features. 8. Understanding of the heat budget process of the glacier. 9. Understanding of methods for glaciological measurements. 10. Knowledge of glaciological hazards like GLOF.
6	Course Outcomes **(CO)**	Student should be able to: **CO1.** Concept of glaciers, its types, characteristics, and importance. **CO2.** Knowledge of glacier and glaciological features. **CO3.** The knowledge of the heat budget of glaciers and its impact on glacial melting processes. **CO4.** Knowledge of different types of glaciological measurements. **CO5.** Knowledge of glaciological hazards.
7	Course Description	To develop a basic understanding of the glaciological process and various technical aspects related to glaciology, glacier dynamics, glaciological hazards.
8	Outline syllabus	CO Mapping
	UNIT I **Global Glacial Chronologies: Snow and Ice**	**CO1**
	Geological, Cenozoic and Recent glaciations, Causes of glaciations Formation and distribution of snow, Snowflakes, Snow measurement techniques, snow water equivalent, snowmelt estimation, Classification of deposited snow, Metamorphism process of deposited snow, Transformation of snow to ice in dry and wet conditions, Snow-firn-ice, Variation of density with depth, Rate of snow crystal growth, Structure of ice crystal, Deformation of a single crystal and polycrystalline ice	
	UNIT II **Glacier**	**CO1/CO2**
	Definition and types of glaciers, Zones in a glacier, Equilibrium line and its importance, Climatic significance, Determining equilibrium line altitude, Reconstructing former equilibrium line altitudes	
	UNIT III **Heat budget of a snowpack and glacier surface**	**CO3**
	Components of heat budget, Heat budget estimations and measurement process in the field, Heat budget on snow, glacier ice and debris	
	UNIT IV **Glacier mass balance measurement and glaciological hazards**	**CO4/CO5**

	Definition and mass balance terms, Measurement of glacier mass balance, Direct measurement, Remote sensing methods, Hydrological methods, Climatic calculations, Mass Balance gradients, Annual mass balance cycles, Mass balance of ice sheet **Glaciological hazards**: Glacial lake and its types, Conditions for the formation of glacial lakes, Glacial lake outburst flood (GLOF) and its causes, Glacial lake outburst floods in Himalaya, GLOF early warning system, Mitigation measures of GLOF			
9	Mode of Examination	Theory		
10	Weightage Distribution	Internal Assessment-I	Internal Assessment-II	End of Semester Examination
		20%	20%	60%
11	Suggested readings			
	1. *Paterson, W. S. B. (1969), The Physics of Glaciers, Third Edition, Perganon Press, Oxford, London, Edinburg.* 2. *Alen, M. H. J. (1992), Glaciers, Cambridge University* 3. *Douglass I. Benn and J. A. E. Davis (1998), Glacier and Glaciation, Dept. of Geography and Topo Science, University of Glasgow, UK* 4. *John Menzies, Modern and Past Glacial Environments, Revised Student Edition, Butterworth Heinemann, Oxford, Auckland* 5. *Nakawo, M. and N. Hayakawa (1998), Snow and Ice Science in Hydrology, Prepared for the 7th IHP Training Course on Snow Hydrology, Inst. for Hydrospheric-Atmospheric Sciences, Nagoya University and UNESCO.* 6. *Matthew R. Bennett and Neil F. Glasser (1996), Glacial Geology-Ice Sheets and Landforms, John Wiley and Sons Ltd. England.* 7. *Hambrey. M. (1994) Glacier Environments, UCL Press Limited, University College London.* 8. *Oerlemans, J. (1989), Glacier Fluctuations and Climatic Change. Kluwer (Dordrecht), 417 pp.*			

CO-PO Compliance Matrix	**PO1**	**PO2**	**PO3**
CO1	**3**	**2**	**2**
CO2	**2**	**3**	**2**
CO3	**2**	**3**	**3**
CO4	**2**	**2**	**3**
Level: 1-Low; 2-Medium; 3-High			