Course Structure and Syllabus

M.Sc. Environmental Science

(2 Years)

Academic Session 2022-23 onwards

(Updated syllabus in accordance with NEP 2020)

Department of Environmental Science

School of Earth Sciences

Central University of Rajasthan

Program Objectives

1. Impart basic knowledge about the environment and its allied problems at the local, regional and global scale.
2. Train the students in 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 program, education, research, industries, consultancy, environmental journalism, etc.
5. Understanding the impacts of climate change, environmental pollution and mitigation strategies.

Program Outcomes

After completion of the program, students will be able to:

1. Use the concepts and methods of ecological, biological, chemical, geological, glaciological and geospatial sciences to solve environmental problems.
2. Apply environmental concepts and methodologies to analyze and understand the interactions between social and environmental processes.
3. Evaluate environmental impacts and assessment using multidisciplinary and advanced approaches.
4. Achieve proficiency in conducting interdisciplinary research and communication skills.
5. Demonstrate an understanding of legal policies, regulatory and ethical considerations relating to the environment.
6. Understand essential mathematical and statistical approaches used to analyze environmental data and apply analytical techniques to solve environmental problems
7. Communicate complex analyses, interpretations and significance effectively in the relevant domain to varied communities.
8. Create moral and ethical awareness to identify ethical issues related to environmental and social aspects.
9. Collaborate in teams with peers and mentors and work with others in diverse group settings, developing flexibility and leadership skills.

M.Sc. Environmental Science (2 year programme) Course Structure

Semester I/VII

S. No.	Course Code	Course Name	Credit	L	T	P
1	ENV401	Fundamentals of Ecology	3	3	0	0
2	ENV402	Environmental Chemistry	3	3	0	0
3	ENV403*	Instrumentation for Environmental Monitoring and Analysis	3	2	1	0
4	ENV404	Environmental Pollution	3	3	0	0
5	ENV405	Biodiversity and Wildlife Conservation	3	2	1	0
6	ENV406*	Environmental Laboratory-I	3	0	0	3
7	ENV4XX	Discipline Elective / MOOCs	3	3	0	0
		Total Credits	**21**			

Semester II/VIII

S. No.	Course Code	Course Name	Credit	L	T	P
1	ENV407	Environmental Geoscience	3	3	0	0
2	ENV408*	Air and Water Quality Management	3	2	1	0
3	ENV409*	Remote Sensing and GIS	3	2	1	0
4	ENV410*	Environmental Impact Assessment and Management	3	3	0	0
5	ENV411*	Environmental Laboratory-II	3	0	0	3
6	ENV412*	Minor Dissertation	3	0	1	2
7	ENV4XX	Discipline Elective / MOOCs	3	3	0	0
		Total Credits	**21**			

Semester III/IX

S. No.	Course Code	Course Name	Credit	L	T	P
1	ENV501	Arid Environment and Desert Meteorology	3	3	0	0
2	ENV502	Environmental Biotechnology	3	3	0	0
3	ENV503	Environmental Toxicology	3	3	0	0
4	ENV504*	Environmental Laboratory-III	3	0	0	3
5	ENV505*	Internship/Skill enhancement	3	0	1	2
6	ENV506	Discipline Elective / MOOCs	3	3	0	0
7	ENV5XX	Ex-Discipline Elective	3	3	0	0
		Total Credits	**21**			

Semester IV/X

S. No.	Course Code	Course Name	Credit
1	ENV507*	Major Dissertation	18
2	ENV5XX	Ex-Discipline Elective / MOOCs	3
		Total Credits	**21**

Total: 84 Credits

Note:

1. A minimum of 5 students are required to run elective courses.
2. Ex-discipline electives can be selected from any department of the university.
3. MOOCs can be selected in consultation with the department.
4. Students are required to take at least one MOOC course in a year.
5. For laboratory courses 1 credit = 2 hours.

* Skill Enhancement/Ability Enhancement courses

Elective Courses I *

S. No.	Course Code	Course Name	Credit	L	T	P
1	ENV431	Soil Science	3	2	1	0
2	ENV432	Agrometeorology	3	3	0	0
3	ENV433	Water and Wastewater Treatment	3	2	1	
4	ENV434	Environmental Legislation	3	3	0	0
5	ENV435	Energy and Environment	3	2	1	0
6	ENV436	Forest Ecology and Management	3	2	1	0
7	ENV437	Sustainable Agriculture and Environmental Practices	3	2	1	0
		Massive Open Online Courses (MOOCs)	3	3	0	0

Elective Courses II**

S. No.	Course Code	Course Name	Credit	L	T	P
1	ENV531	Geo-informatics for Forest Management	3	2	0	1
2	ENV532	Occupational Hazards	3	2	1	0
3	ENV533	Aquatic and Chemical Ecology	3	2	1	0
4	ENV534	Glaciology and Glacial Processes	3	3	0	0
5	ENV535	Environmental Stress on Vegetation	3	2	0	1
6	ENV536	Carbon Capture and Sequestration Technology	3	2	1	0
		Massive Open Online Courses (MOOCs)	3	3	0	0

These courses will be opened for students of VII /I and VIII/II semester

****These courses will be opened for students of IX/III and X/IV semester***

Instructions to the students regarding MOOCs

1. The courses are circulated on the website https://swayam.gov.in in the month of June and November every year for the forthcoming semester.
2. Every student has to pass a selected MOOC course within the stipulated time period. The passing of a MOOC course is mandatory for the fulfillment of the award of the degree.
3. A student has to register for the course for which he/she is interested and eligible which is approved by the department with the help of course coordinator.
4. The student must read all the instructions for the selected course on the website, get updated with all key dates of the concerned course and must inform his/her progress to their course coordinator.
5. The students should note that there will be a weightage of Assessment/quiz etc. and final examination appropriately as mentioned in the instructions for a particular course.
6. A student must claim the credits earned in the MOOC course in his/her mark sheet in the examination branch by forwarding his/her application through the Head of the Department.
7. The student may contact the MOOCs coordinator of the department for any further clarification.

ENV401: Fundamentals of Ecology **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VII & I			
Course: Fundamentals of Ecology			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End of Semester:** 60 Marks	Theory: 03

Course Pre-requisite: Student should have basic knowledge of Biology and Environmental Science.

COURSE OBJECTIVES	1. Impart knowledge on the different ecological concepts and disciplines of ecology 2. Understand the ecosystem, population and community ecology and its relevance for the environmental segments and factors. 3. Understand the interactions of organisms and their environments and, the consequences of these interactions for population, community, and ecosystems' functional dynamics. 4. Apply the fundamentals of ecology for forming the foundation of ecological theories.
COURSE OUTCOMES(CO)	By the end of the course, students will be able to: **CO1.** Raise an awareness about the living organisms and their interaction with the environment **CO2.** Understand ecological concepts and major disciplines of ecology **CO3.** Build central ideas behind the ecology of individuals, populations, communities and ecosystems **CO4.** Develop critical thinking through scientific evidences to understand ecological patterns, processes and ecological problems **CO5.** Apply the basic knowledge in ecological assessment and research. **CO6.** Get the opportunities of employment in the sector of Ecology and ecological monitoring

COURSE CONTENT	**Hours**
UNIT I Definition, principles, and scope of Ecology and environment. Abiotic factors: physico-chemical factors, Light, Temperature, pH, Salinity, Physiography, Fire, Nutrients.	**7**
UNIT II 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. Negative and Positive interactions between individuals, species and communities with examples.	**8**
UNIT III Concept of strain, ecotypes, species, population and community. Characteristics and parameters to understand populations. Lotka-Volterra model, Metapopulations, niche concept, r and K selection theory. Ecological niche, keystone species, dominant species, invasive species, ecotone and edge effect.	**8**
UNIT IV Community organization- analytical characters, synthetic characters, C-S-R Model, Species diversity and measurement of diversity. Community dynamics- Models of succession. McArthur Hypothesis of ecosystem stability. Genecology and range extensions.	**7**

UNIT V The ecosystem concept, abiotic and biotic components. Structure and functions of ecosystems. Solar energy input in an ecosystem, Ecosystem metabolism. Energy Flow models in an ecosystem.	**7**
UNIT VI Primary and secondary production, measuring primary production, the efficiency of econdary production and co-existence. Concept of food chain & food webs, Biomes of the world and microbiome. Biogeochemical cycles (C, N, P, S etc.).	**8**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End of Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Odum, E. P. (1991). Fundamentals of Ecology, W. B. Saunders, USA. Indian Reprint 1996 Natraj Publishers, Dehradun.*
2. *Sharma, P.D. (2015). Ecology and Environment. Rastogi Publications.*
3. *Singh, J.S., Singh, S.P. & Gupta S.R.(2014). Ecology, Environmental Science & Conservation, S Chand & Company Limited, Delhi.*

Reference Books:

1. *Krebs, C. J. (2008). The Ecological World View. CSIRO Publishing. Callingwood, Australia.*
2. *Daniel, B. B. & Edward, A.K. (2007). Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA.*
3. *Odum, E.P. (1997). Ecology: A Bridge between Science and Society. Sinauer Associates,Inc., USA.*

ENV402: Environmental Chemistry **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) **SEMESTER VII & I**			
Course: Environmental Chemistry			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of chemistry.			

COURSE OBJECTIVES	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 4. Understand the interactions of varied spheres of environment
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Understand the interconnections between environmental matrices **CO2**. Apply fundamental concepts of chemistry to analyze 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. **CO5**. Characterize the types of toxic chemicals present in environment **CO6**. Understand the effect of human activities on the natural chemical processes.

COURSE CONTENT	**Hours**
UNIT I Introduction to Environmental Chemistry; Environmental segments-Atmosphere, Hydrosphere, Lithosphere, Biosphere; Interaction between different environmental spheres	**5**
UNIT II Structure and composition of the atmosphere; Tropospheric chemistry - Photochemical 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.	**10**
UNIT III 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.	**10**
UNIT IV Soil formation; Soil properties; Soil minerals; Soil organic matter; Soil water; Soil aeration; Soil pH and buffer capacity; Soil acidity and alkalinity; Soil colloids; Ion-exchange processes; Soil Nutrients.	**10**
UNIT V Toxic organic and inorganic chemicals of environmental concern; sources, transport processes and receptors	**5**

UNIT VI Anthrosphere: Components; Integration in total environment and influence on other environmental spheres; Green chemistry			**5**
ASSESSMENT			
PART A	Internal Assessment-I	UNIT- I,II	20% (Written Test)
	Internal Assessment-II	UNIT- II,III	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Stanley, M. E. (2011). Fundamentals of environmental chemistry. CRC press.*
2. *Baird C. & Cann, M.(2008). Environmental Chemistry. W.H. Freeman and Company.*
3. *De, A.K. (2000). Environmental Chemistry, New Age International (P) Ltd. Publishers,New Delhi.*

Reference Books:

1. *Macalady, D.L. (1999). Perspectives In Environmental Chemistry, J. Chem. Educ.*
2. *Yen, T.F. (1998). Environmental Chemistry: Essentials of chemistry for Engineering Practice, Prentice Hall.*
3. *vanLoon, G.W. & Duffy, S.J.(2017). Environmental Chemistry: A Global Perspective, 4th Edition, Oxford.*

e-Resources:

https://chem.libretexts.org/Bookshelves/Environmental_Chemistry
https://www.uvm.edu/~gpetrucc/courses/chem196/Textbooks/
https://geo.libretexts.org/Bookshelves/Soil_Science

ENV403: Instrumentation for Environmental Monitoring and Analysis (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VII & I			
Course: Instrumentation for Environmental Monitoring and Analysis			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Students will have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Develop an understanding of the principles of sampling, chemical analysis, and instrumentation which is more important than knowing 'specific how'. 2. Introduce the students with the basic aspects of the environmental chemical data collection process, such as systematic planning, sensible field procedures, solid analytical chemistry. 3. Evaluation of data quality in the context of their intended use. 4. Expose students to the fundamental instrumental techniques that are part of environmental projects.
COURSE OUTCOMES (CO)	By the end of the course, students will be able to: **CO1**. Develop a comprehensive detailed procedure for common field sampling tasks, and practical tips for all project tasks. **CO2**. Learn the effective role of obtaining data of scientifically reliable and legally defensible nature by exercising good laboratory practices. **CO3.** Recognize the environmental data acquisition and be able to obtain data of intended quality. **CO4.** Comprehend the basics of various instrumentation techniques related to electroanalytical and potentiometric applications in environmental analysis. **CO5.** Know the basics of various instrumentation techniques related to spectrophotometry and application. **CO6.** Understand chromatography and its application in environmental analysis.

COURSE CONTENT	**Hours**
UNIT I Fundamentals of environmental sampling and analysis, environmental sampling design for air, water and soil matrices.	**7**
UNIT II Environmental sampling technique, fundamentals of sample preparation for environmental analysis, good laboratory practices.	**7**
UNIT III Environmental data acquisition, quality assurance/quality control of environmental analysis, Environmental data analysis, concept of uncertainty and error estimation	**7**
UNIT IV Electrochemical methods for environmental analysis, Principles of electroanalytical methods, potentiometric applications in environmental analysis	**8**
UNIT V Principles of Spectroscopy, UV-Visible Spectroscopy, Infrared Spectroscopy, Practical	**8**

Aspects of UV-Visible and Infrared Spectrometry; Principles of Atomic Spectroscopy, Instruments for Atomic Spectroscopy, Selection of the Proper Atomic Spectroscopic Techniques.	
UNIT VI Principles of electroanalytical methods; Potentiometric applications in environmental analysis, Ion Selective Electrodes; Instruments of chromatographic methods, common detectors for chromatography, applications of chromatographic methods in environmental analysis	**8**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT, I - VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Reeve, R.(2002). Introduction to Environmental Analysis. John Willey & Sons.*
2. *Skoog, D. A., Holler, F.J., &Crouch, S.R. (2006) Principles of Instrumental Analysis, Brooks Cole.*
3. *Chatwal, G. R., & Anand, S. K. (2007). Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi.*

Reference Books

1. *Keith, L. H. (2017). Environmental sampling and analysis: a practical guide. Routledge.*
2. *Csuros, M. (2018). Environmental sampling and analysis: lab manual. Routledge.*

e-Resources

https://cpcb.nic.in/displaypdf.php?id=c291cmNlYXBwb3J0aW9ubWVudHN0dWRpZXMucGRm

https://cpcb.nic.in/manual-monitoring/

ENV404: Environmental Pollution **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VII & I			
Course: Environmental Pollution			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Students should have basic knowledge of science.			

COURSE OBJECTIVES	1. Understand air pollution, types and sources of air pollutants, including various impacts on the environment and human health 2. Provide a thorough concept on factors affecting water quality, major water pollutants, global water crisis, and treatment of wastewater 3. Enable students to understand types of soil, impact of industrialization and urbanization on soil quality and control measures 4. Understand present environmental pollutions and impacts at national and international conventions. In addition, knowledge of various control measures adopted for the abatement of pollution.
COURSE OUTCOMES (CO)	By the end of the course, students will be able to: **CO1**. Understand the concept of pollution and its impacts on humans, society and the environment **CO2** Link air pollution, types and sources of air pollutants with various impacts on the environment and human health **CO3** Gain familiarity with meteorological implications on the dispersion of air pollution and reasons for conversion from local to global scale **CO4** Learn about water pollution, sources, causes and its effect on humans and the environment **CO5** Recognize soil pollution, sources, its consequences, and mitigating measures **CO6** Understand solid waste classification, its sources and methods of disposal

COURSE CONTENT	**Hours**
Unit I Definition and Types of pollution, General discussion on the pollution perception, Causes and Sources of Pollution, Effect of pollution on the global, regional and local scale; Impacts of pollution on human health and environment;	**6**
Unit II Primary and Secondary Pollutants, Automobile Pollution, Industrial Pollution, Ambient Air Quality Standards and indices; Effect of pollution on the global, regional and local scale	**7**
Unit III Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); meteorological aspects of air pollution- Temperature profiles in the atmosphere, Lapse rate, stability and mixing heights, temperature inversion, wind profiles, turbulent diffusion, topographic effects, Plume behaviour, dispersion of air pollutants, Gaussian plume model, line source model and area source model	**10**

Unit IV Point and Non-point sources of pollution, significant water pollutants, Water Quality requirements for different uses; Water quality standards Indian standards for drinking water, Drinking water treatment, Wastewater Treatment, global water crisis Issues, effects of water pollution and its control	**8**
Unit V Soil composition, Classification of soil types, Causes of soil degradation, Urbanization and land degradation; Impact of Modern Agricultural Practices on Soil, Effect on Environment and Life sustenance; Abatement measures, Effects and Control measures	**7**
Unit VI Solid waste Classification, Sources of Solid waste, Different methods of Disposal, Control methods- incineration, landfill, the effect of urban and industrial solid waste on the environment	**7**

ASSESSMENT			
PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Test/Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT - I -VI	60% (Written Test)

SUGGESTED READINGS

Text Books

1. *Reddy, M.A. (2010). Textbook of Environmental Science and Technology, BS Publications.*
2. *Wright, R. T. (2008). Environmental Science- Towards a sustainable future, PHI Learning, New Delhi.*
3. *De, A.K. (2000). Environmental Chemistry, New Age International (P) Ltd. Publishers, New Delhi.*

Reference Books

1. *Peirce, J.J., Vesilind, J.J., & Weiner, R. (1997). Environmental Pollution and Control, 4th Edition, Publisher Butterworth-Heinemann.*
2. *Pepper, I., Gerba, C., & Brusseau, G. (2006). Environmental and Pollution Science, 2nd Edition, Academic Press.*
3. *Rao, C.S. (2018). Environmental Pollution Control Engineering, 3rd Edition, New Age International Publishers.*

e-resources

https://archive.ipcc.ch/ipccreports/tar/wg2/index.php?idp=356
https://wcedeportal.co.za/eresource/71131
http://osou.ac.in/eresources/Air%20pollution.pdf

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ENV405: Biodiversity and Wildlife Conservation (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VII & I			
Course: Biodiversity and Wildlife Conservation			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End of Semester:** 60 Marks	Theory: 03
Course Pre-requisite: Students should have basic knowledge of Biology.			

COURSE OBJECTIVES	1. Impart knowledge to become part of professional organizations working in the field of conservation and environmental protection. 2. Generate a skilled postgraduate who can research in the field of Biodiversity, Wildlife biology, and nature conservation. 3. Provide an alternate avenue for students to specialize as "environmental entrepreneurs" in areas such as environmental audits, Environmental Education, Ecotourism, etc. 4. Develop critical and analytical thinking for decision-making in biodiversity and wildlife management.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Raising awareness about the biodiversity and their conservation with in environment. **CO2.** Enhance the understanding of wildlife conservation and human conflicts. **CO3.** Build central ideas behind the conservation of biodiversity and wildlife populations, communities and ecosystems. **CO4.** Develop of critical thinking through scientific evidences to understand biodiversity and wildlife patterns. **CO5.** Apply the basic knowledge in ecosystem assessment, management and research. **CO6.** Get the opportunities of employment in the sector of ecological management.

COURSE CONTENT	**Hours**
UNIT I Biodiversity - Concept and definition, Causes of Biodiversity, Values of Biodiversity, Threats to Biodiversity, Taxonomy and the future of Plant Diversity, Species Diversity and Conservation, Ecosystem concept, Landscape heterogeneity, Restoration Ecology, Protected Areas and management.	**7.5**
UNIT II Biodiversity Conservation and Climate Change - Introduction to Conservation, Importance of conservation, Conservation challenges in the Twenty first century, Evaluation of priorities for conservation of habitats and species, Climate and Climate Change, Global Biological Impacts of Climate Change, Conservation Planning and Climate Change, Geo-informatics and Biodiversity Assessment, Ecosystems and Wetlands.	**7.5**
UNIT III Introduction and History of Wildlife Conservation, Global as well as Indian Prospective, Values and Ethics in Wildlife Conservation, Habitat Ecology, Field Techniques, Wildlife Behavior, Avian ecology, Sampling designs for population estimation, Current issues in wildlife conservation with case studies.	**7.5**

UNIT IV Biodiversity Conservation, Human Society and Ethics, Humans and sustainability, Economics and biodiversity, Biodiversity and Human Health, Biodiversity and Traditional Health Systems.	**7.5**
UNIT V Conservation Policies and Law, Protection of Forest and Wildlife, Biodiversity and Patent, Laws Concerning Forest, Wildlife and People, International Law and Constitutional Frame for Conservation Policies, Biostatistics.	**7.5**
UNIT VI Climate change mitigation & adaptation, Basic concepts and mechanisms, Climate Change Policy-Mitigation, Climate Change Policy-Adaptation, International response, Linking biodiversity, environment and human being, Ethical issues related to biodiversity and environment, Corporate Social Responsibility, Sustainable Ecotourism.	**7.5**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End of Semester Examination	UNIT- I-V	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Dyke, F.V. (2008). Conservation Biology Foundations, Concepts, Applications, 2nd Edition. Springer.*
2. *Singh, G. (2008). Plant Systematics: Theory and Practice. Oxford & IBH Publishing Co. Pvt. Ltd.*
3. *Primack, R. (2014). Essentials of Conservation Biology, 6th Edition. Sinauer Associates, Inc., USA*
4. *Groom, M. J., Meffe, G. R. & Carroll, C. R. (2006). Principles of conservation biology. Sinauer associates, Inc., USA.*

Reference Books:

1. *Stuart, C., Spalding, M. & Jenkins, M. (2008). The world's Protected Areas: Status, Values and prospects in 21st century.*
2. *Chivian, E. & Bernstein, A. (2008). Sustaining life: How human health depends on biodiversity. Oxford University Press.*
3. *Narendran, T. C. (2006). An Introduction to Taxonomy. Zoological Survey of India, Kolkata.*

EVS 406: Environmental Laboratory-I **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VII & I			
Course: Environmental Laboratory-I			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Practical:** 6 hours/week	**End of Semester:** 100 Marks	Practical: 03
Course Pre-requisite: Student should have basic knowledge of Environmental Science.			

COURSE OBJECTIVES	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 aspects of ecology, and analysis of soil, water, and air samples. 4. Learn practical methods for analysis of environmental samples.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Develop analytical abilities for environmental and ecological analysis parts of laboratories in higher studies, professional bodies and research institutes. **CO2.** Understand the appropriate methods and principle behind the practical protocols. **CO3.** Learn sampling methods and analysis of soil, air and water samples. **CO4.** Optimize and choose appropriate methods for environmental analysis. **CO5.** Conclude the results and prepare scientific reports/ practical record books. **CO6.** Connect knowledge of theoretical courses with the practical implications.

COURSE CONTENT	**Hours**
UNIT I Determination of abundance, dominance and frequency of a grassland ecosystem; Determination of diversity index of aquatic ponds and terrestrial ecosystem	**7**
UNIT II Understanding the community & population structure in addition to succession phenomena in the field; Determination of primary productivity of any ecosystem.	**8**
UNIT III Air analysis: Oxides of Nitrogen, Ozone and Sulphur, SPM and RSPM	**7**
UNIT IV Water analysis: pH, Electrical Conductivity, Turbidity, Total Suspended Solids, Total Dissolved Solids, Dissolved Oxygen, Acidity and Alkalinity	**8**
UNIT V Soil analysis: Moisture content, Organic carbon, Organic matter, Water holding capacity, Particle size analysis; Bulk density; Loss-on ignition	**7**
UNIT VI Know-how and demonstration of instruments, calibration and standard curves for spectrophotometry and chromatography. Visiting the analytical instrumentation facility e.g. AAQMS and Meteorological laboratory.	**8**

ASSESSMENT		
End of Semester Examination	UNIT- I-VI	100% (Practical Exam + Viva Voce)

SUGGESTED READINGS

Reference Books:

1. *Handerson, P. A. (2009). Practical Methods in Ecology. Wiley Publishers*
2. *Lodge, J. P. (2020). Methods of Air Sampling and Analysis. 3rd Edition CRC Press.*
3. *Page, A. L. (1983). Methods of soil analysis. American Society of Agronomy, Inc. Soil Science Society of America, Inc. Publisher.*
4. *APHA (2017). Standard Methods for the Examination of Water and Wasterwater, 23rd Edition APHA Press.*

ENV407: Environmental Geoscience (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Environmental Geoscience			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of science.			
COURSE OBJECTIVES	1. Understand fundamentals of geoscience and the evolution of earth and its interiors 2. Understand the geological processes and related hazards, geological division, physical geology of India 3. Understand primary mineralogy and mining processes 4. Understand the impacts of mining on the environment and human health		
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Understand the fundamentals of geoscience and evolution of earth and its interiors **CO2.** Gain knowledge about the geological division and physical geology of India **CO3.** Learn the mechanism of surface process and their agents like weathering, erosion, transportation, etc. **CO4.** Link geological processes and related hazards like earthquakes, landslides, avalanches, GLOF, etc. **CO5.** Understand the concepts of groundwater processes and groundwater flow mechanism **CO6.** Gain basic understanding of mineralogy and mining processes and impacts of mining on environment and human health		

COURSE CONTENT	**Hours**
UNIT I Introduction of earth and its position in the solar system, the evolution of the earth through ages, Earth's Interiors with the details of layers (core, mental, and crust); Earth systems, Physical features of the earth,	**7**
UNIT II Geological division of India, Northern mountains and northern plains, Peninsular plateau, coastal plains and islands	**7**
UNIT III Surface processes and their agents: Weathering, erosion, transportation. Principles of geomorphology and landforms related to aeolian, fluvial, glacial, and lacustrine processes.	**5**
UNIT IV Volcanoes, Plate Tectonics, Earthquake, Tsunami, Landslide, Mass wasting, Mudflow, Avalanches, Glacier outburst Flood (GLOF)	**9**
UNIT V Water Cycle and Terminology, Classification of aquifers and confining layers, hydraulic properties of aquifers, saturated zone, water table and piezometric surface, Hydraulic conductivity, Groundwater movement and topography, Groundwater flow,	**10**

cone of depression and Groundwater Recharge	
UNIT VI Rocks types and classification - Igneous, Sedimentary, Metamorphic; Minerals and Coal, Mining, Tunnelling, Exploration and Exploitation; Mining related environmental concerns	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT - I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Johnson, C., Matthew, D., Affolter, P.I., & Mosher, C. (2017). An Introduction to Geology. Salt Lake Community College.*
2. *William L. (2012). Fundamentals of Geophysics. Cambridge university Press.*
3. *Mahapatra G. B. (2019). A Textbook of Geology.*

Reference Books:

1. *Grotzinger, J., & Thomas, H.J. (2007). Understanding the Earth, 5th Edition. FRANK PRESS and RAYMOND SIEVER, , W. H. Freeman& Co.*
2. *Monroe, J.S. & R. Wicander (2001). Physical Geology, 4th edition. Brooks/Cole Pacific Grove CA, 2001*
3. *Keller, E.A. (2007). Introduction to Environmental Geology, 4th Edition. Prentice Hall of India.*

e-resources

https://groundwater.ucdavis.edu/files/156562.pdf
https://opengeology.org/textbook

ENV408: Air and Water Quality Management (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Air and Water Quality Management			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Train the students about the determination of the air and water quality parameters. 2. Understand the environmental objectives for maintaining air and water quality standards. 3. Understand the complete procedure for getting ISO certification for achieving environment and quality standards. 4. Learn about quality control standardizing bodies for management of air and water quality.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1**. Understand the atmosphere and hydrosphere. **CO2.** Evaluate various physicochemical and biological parameters of air and water quality. **CO3.** Learn about various quality control standardizing bodies for management of air and water quality. **CO4.** Assess the validity and limitations of air and water quality parameters. **CO5.** Know about various treatment technologies for air and water quality. **CO6.** Identify potential sources of pollution of air and water matrices.

COURSE CONTENT	**Hours**
UNIT I Concept of atmosphere and hydrosphere; Criteria air pollutants, air quality standards, National Ambient Air Quality Standards; Water quality standards; Fundamentals of air and water pollutants transport dynamics.	**7**
UNIT II Pollutant fate and transport, air quality surveillance network; Indoor air pollution and its quality management; Prediction and assessment of impacts on the air environment: Basic information on air quality issues.	**8**
UNIT III Water quality standards (physical, chemical, microbiological, radiological); Water quality modeling; Emerging pollutants in water; Pollutant fate and transport.	**8**
UNIT IV Current scenario of air and water pollution effects; factors affecting the assessment of pollution; Air Quality models - Gaussian convection-diffusion model for point, line and areal sources.	**7**
UNIT V	**7**

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 VI Air quality control measures, control of specific gaseous pollutants. water quality assurance, advanced water treatment techniques, control of emerging pollutants, analytical techniques.			**8**
ASSESSMENT			
PART A	Internal Assessment-I	UNIT-I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT, I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Baird, C., & Cann, M. (2008). Environmental Chemistry. W.H. Freeman and Company.*
2. *Reeve, R. (2002). Introduction to Environmental Analysis. John Willey & Sons.*
3. *Skoog, D. A., Holler, F.J., & Crouch, S.R. (2006). Principles of Instrumental Analysis. Brooks Cole.*
4. *De, A.K.(2000). Environmental Chemistry, New Age International, New Delhi.*

Reference Books

1. *Keith, L. H. (2017). Environmental sampling and analysis: a practical guide. Routledge.*
2. *Csuros, M. (2018). Environmental sampling and analysis: lab manual. Routledge.*
3. *Chatwal, G. R., & Anand, S. K. (2007). Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi.*

e-Resources

https://cpcb.nic.in/displaypdf.php?id=c291cmNlYXBwb3J0aW9ubWVudHN0dWRpZXMucGRm

https://cpcb.nic.in/manual-monitoring/

ENV409: Remote Sensing and GIS **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Air and Water Quality Management			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Students should have basic knowledge of computer/ software.			

COURSE OBJECTIVES	1. Train the students in practical and executable solutions to the challenges of the emergent field of Remote Sensing and GIS. 2. Impart the students with a strong base of knowledge that makes them suitable both for industries, teaching, and research. 3. Apply the fundamental principles for a successful profession and/or for higher technical education based on mathematical, scientific and engineering principles, to solve realistic and field problems that arise in engineering and non-engineering sectors. 4. Students will be installed with ethical feeling, encouraged to make decisions that are safe and environmentally-responsible and also innovative for societal improvement.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Carry out research/developmental work to solve real-world geospatial problems. **CO2.** Identify specific data and methodologies for effective mapping and evaluation of natural resources. **CO3.** Illustrate spatial and non-spatial data features in GIS and understand the map projections and coordinates systems **CO4.** Design systems for decision making and work in a team using geospatial tools to achieve project objectives. **CO5.** An ability to share theoretical and practical knowledge in both teaching and research as well as in industries. **CO6.** Apply knowledge of GIS and understand the integration of Remote Sensing and GIS.

COURSE CONTENT	**Hours**
UNIT I Remote Sensing Concepts, Electromagnetic Radiation (EMR), Atmospheric Windows, Spectral Signatures, Resolutions, Platforms, Satellites, Sensors, and Specifications	**7**
UNIT II Digital Image Processing System, Image Enhancement, Transformation and Image Classifications, Image Interpretations (Optical, Thermal & Radar)	**7**
UNIT III 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.	**8**

UNIT IV GPS-An Overview, Positioning, System Segmentation, Augmentation, DGPS, & GNSS/IRNSS Applications.	**7**
UNIT V 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	**8**
UNIT VI Advances in Remote sensing: 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.	**8**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT, I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Burroughs, P. A. & Rachael, M. (1998). Principles of Geographical Information Systems" Oxford University Press, New York.*
2. *Jensen, J.R. (1996). Introductory Digital Image Processing, A remote sensing perspective. Prentice Hall Series in GIS, USA.*
3. *Lillesand, T. M. & Kiefer, R. W. (2007). Remote Sensing and Image Interpretation, 4th Edition. John Wiley and Sons, New York.*

Reference Books

1. *Sabin, F.F. J. (2007). Remote Sensing – Principles and Interpretation", W.H. Freeman & Co.*
2. *Chang, K. (2007). Introduction to Geographic Information Systems, Tata McGraw Hill, New Delhi.*
3. *Gopi, S. (2005). Global Positioning System: Principles and Applications. McGraw Hill Publishers.*

e-Resources

https://cpcb.nic.in/displaypdf.php?id=c291cmNlYXBwb3J0aW9ubWVudHN0dWRpZXMucGRm

https://cpcb.nic.in/manual-monitoring/

ENV410: Environmental Impact Assessment and Management (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Environmental Impact Assessment and Management			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Explain the basic principles of environmental impact assessment 2. Understand the different steps within environmental impact assessment. 3. Discuss the implications of current jurisdictional and institutional arrangements in relation to environmental impact assessment 4. Understand how to liaise with and the importance of stakeholders in the EIA process
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Know 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. **CO5.** Know the basic mechanisms of audits and audit procedures **CO6.** Assess the methods of LCA and standardization including ISO

COURSE CONTENT	**Hours**
UNIT I Objectives and development of EIA. Benefits of EIA, Indian directions of EIA**.** Rapid and comprehensive EIA perspectives. Sources and collection of data for EIA.	**7**
Unit II Environmental Clearance 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.	**8**
Unit III Environmental Management Systems (EMS), ISO 14000 (EMS). HACCP, Life Cycle Analysis (LCA)	**8**
Unit IV Components of Environmental Management System-Objectives, Policies, Implementation and Review. Environmental appraisal, accounting and	**7**

environmental audit	
Unit V Public Participation; Concept and significance of Public Hearing, Social impact assessment (SIA), Strategic Environmental Assessment (SEA), Case studies of specific industries.	**8**
Unit VI Post project analysis restoration and rehabilitation methodologies, Mitigation criteria, Project modification, concept of COE & COO, Risk assessment.	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III , IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books

1. *Anjaneyulu, Y. & Manickam, V. (2002).Environmental Impact Assessment Methodologies. B.S. Publications.*
2. *Cutter, S. L. (1999). Environmental Risks and Hazards. Prentice Hall of India, New Delhi.*
3. *Glasson, J., Therivel, R. & Chadwick, A. (2006). Introduction to Environmental Impact EIA. Routledge, London.*
4. *Rao, P. S. & Rao, P.M. (2000). Environmental Management and Audit. Deep and Deep Publications.*

Reference Books

1. *Morgan, R. K. (2012). Environmental impact assessment: the state of the art. Impact assessment and project appraisal, 30(1), 5-14.*
2. *Morris, P. & Therivel R. (2001). Methods of Environmental Impact Assessment. 2nd edition. Spon Press London.*

e-Resources

https://www.iisd.org/learning/eia/wp-content/uploads/2016/06/EIA-Manual.pdf

ENV 411: Environmental Laboratory-II (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Environmental Laboratory			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Practical:** 6 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Practical: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Understand the concept of sampling methods, ways to obtain scientifically reliable data and data quality 2. Provide hands-on experience with the instruments which are used for environmental sampling and analysis. 3. Perform qualitative and quantitative analysis of water and air quality parameters. 4. Learn the interpretation of results for problem identification.
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 **CO5.** Assess the synoptic view of the study site **CO6.** Understand application of different earth observation datasets having varied resolutions

COURSE CONTENT	**Hours**
Unit I Sampling methods**,** physicochemical, biological parameters of water	**7**
Unit II Analysis of DO, BOD, COD, MPN, Phosphate, Nitrate, fluoride, Heavy metals, etc.) in water	**8**
Unit III Water quality assurance, advanced water treatment techniques, control of emerging pollutants, analytical techniques.	**7**
Unit IV Monitoring of air quality parameters (O3, SOx, NOx, NH3, SPM, RSPM) etc. outdoor and indoor sampling of air, NAAQMS, principles, workings and applications of High Volume Dust Sampler, Respirable Dust Sampler	**7**
Unit V Introduction to Remote Sensing and GIS softwares, Geo-referencing, Mosaicing, Fusion (Merging of high and low spatial and spectral resolution images), Image Sub-setting, Digital Image Processing.	**8**
Unit VI Preparation of Land Use/Land Cover Maps using visual and digital interpretation, Image Classification Supervised Unsupervised, Vectorizing and different functions	**8**

of vector data using open source GIS softwares.		
ASSESSMENT		
End Semester Examination	UNIT- I-VI	100% (Practical Exam + Viva voce)
SUGGESTED READINGS		

Reference Books

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. *Lawrence H. K. (2017). Environmental Sampling and Analysis: A Practical Guide 1st Edition.*
3. *Chaurasia, S., & Gupta, A.D. (2014). Handbook of water, air and soil analysis. International E-publication, 123.*
4. *Maiti S. K. (2018). Handbook of Methods in Environmental Studies: Water and Waste Water Analysis.*
5. *Gopi S. (2005). Global Positioning System: Principles and Applications. McGraw Hill Publishers. 8.*
6. *Quattrochi, D. A., & Luvall, J. C. (Eds.). (2004). Thermal remote sensing in land surface processing. CRC Press.*
7. *Borengasser, M., Hungate, W. S., & Watkins, R. (2007). Hyperspectral remote sensing: principles and applications. CRC press.*
8. *Mitchell, A. (2012). The ESRI Guide to GIS Analysis, Volume 3: Modeming Suitability, Movement, and Interaction. Redlands, CA, ESRI Press.*

ENV412: Minor Dissertation **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Minor Dissertation			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Practical**: 6 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	**Practical: 03**

Course Pre-requisite: Student should have completed VII/I semester of Int. M.Sc./M.Sc. programme.

COURSE OBJECTIVES	1. To develop ability in the students to apply some of the techniques/principles have been taught. 2. The project must cover at least any one area suggested below: a. Experimental Design b. Environmental monitoring and Assessment c. Analysis of environmental matrices d. Industry oriented basic surveys/testing/analysis etc. e. Problem solving using multi-disciplinary science
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1**.Practice acquired knowledge within the selected area of science/technology for project development. **CO2.** Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach. **CO3.** Reproduce, improve and refine scientific/technical aspects **CO4.** Work as an individual or in a team in development of projects. **CO5.** Communicate and report effectively project related activities and findings. **CO6.** Formulate and implement innovative ideas for social and environmental benefits.

COURSE CONTENT	**Hours**
This course envisages that a student will acquire the ability to use a wide range of the skills learned during their course of study. A student is required to carry out the project work related to Environmental Science, under the guidance of a supervisor.	**90 h**

ASSESSMENT	
End Semester Examination	Project Report Submission, Presentation and Viva-Voce

ENV501: Arid Environment and Desert Meteorology (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Arid Environment and Desert Meteorology			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Understand the process of genesis and dynamics of the desert and its characteristics 2. Learn atmospheric and surface energy budgets in the desert environment. 3. Learn severe weather conditions in the desert environment and the ecological status of the arid area. 4. Learn the effects of deserts on the environment and humans.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Understand the concept of arid environment and its characteristics. **CO2.** Understand the surface energy budget of the desert and its implication on desertification. **CO3.** Apply the concept of the severe weather conditions in the desert and ecological status of arid area. **CO4.** Gain familiarity with the ecological status of desert. **CO5.** Identify the cause of desertification and control measures. **CO6.** Assess the impact of the deserts on the environment and human

COURSE CONTENT	**Hours**
UNIT I Characteristics of desert and desert biomes;, causes of aridity, geomorphology, land use and soil.	**8**
UNIT II Dynamic feedback mechanisms- cause and sustaining deserts; Surface energy budget of the desert; Inter-annual variability in aridity (drought).	**8**
UNIT III Dust storms and sandstorms, monsoon patterns in deserts, rainstorms, floods, and debris flows; desert severe weather.	**8**
UNIT IV Desert microclimate, arid ecology concept and status; Ecology of arid zone in India.	**7**
UNIT V Desertification, causes and effects, climate change and desertification.	**7**
UNIT VI National and International policies and convention for combating desertification.	7

ASSESSMENT			
PART A	Internal Assessment-I	UNIT-I ,II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)

PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *WARNER, T. T. (2004). Desert Meteorology. Cambridge university press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo*

Reference Books

1. *Nicholson, S.E. (2011). Dryland Climatology Publisher Cambridge University Press.*
2. *Sharma, A. K., & Tewari, J.C. (2009). Arid zone forestry with special reference to Indian hot arid zone." Forests and Forests Plants. Eolss, Publishers Company, UK 90-130.*

e-Resources

https://www.unccd.int/

ENV502: Environmental Biotechnology (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Environmental Biotechnology			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. 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. 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. Train the students about conservation of resources via recycling of waste materials and recovery of valuable products such as metals and oils.
COURSE OUTCOMES (CO)	By the end of the course, the student will 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. **CO5.** To understand basic mechanisms of bioremediation **CO6.** To develop methods for improved biological processes

COURSE CONTENT	**Hours**
UNIT I Genetic material, structure, and function, recombinant DNA technology, genetically engineered microorganisms (GEMs), PCR, Gel Electrophoresis, SDS-PAGE, Gene Banks	**8**
Unit II Bioremediation, phytoremediation, biosorption, an integrated treatment system for biodegradation of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons, pesticides and organic compounds, bio- transformation of heavy metals	**8**
Unit III Enzyme Technology, bioreactors, batch and continuous reactors, and formulation of bacterial and fungal enzymes, enzyme kinetics, purification, enzyme assisted bioremediation	**8**
Unit IV	**7**

Bioprocess optimization, OVAT (One Variable at a Time method), Design of Experiments	
Unit V Nanotechnology assisted bioremediation, biotechnology for environmental management	**7**
Unit VI Oil field biotechnology, biomass production, biogas, and biofuel production, microorganisms in mineral and energy recovery	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I& II	20% (Written Test)
	Internal Assessment-II	UNIT-III & IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT, I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books

1. *Michael P. J. (2001). Microbiology, 5th Edition. McGraw Hill Education.*
2. *Pepper, I.L. & Gerba, C.P. (2005). Environmental Microbiology - Laboratory Manual. Elsevier, USA.*
3. *Ratledge, C. & Kristiansen, B. (2002). Basic Biotechnology, 2nd edition. Cambridge University Press, Cambridge, UK.*
4. *Rittman, B. & McCarty, P. L. (2000). Environmental Biotechnology: Principles and Applications, 2nd edition. Tata McGraw-Hill, USA.*
5. *Christon J. H., Ronald, L. C., Guy R. K., & Michael J. M. (2001). Manual of Environmental Microbiology, 2nd edition. ASM Press.*

Reference Books

1. *Jördening, H. J., & Winter, J. (Eds.). (2005). Environmental biotechnology: concepts and applications.*
2. *Bhattacharyya, B. C., & Banerjee, R. (2007). Environmental biotechnology. USA: Oxford university press.*

e-Resources

https://www2.hcmuaf.edu.vn/data/quoctuan/Environmental%20Biotechnology%20-%20Theory%20and%20Application,%20G%20M%20Evans%20&%20J%20C%20Furlong.pdf

ENV503: Environmental Toxicology **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Environmental Toxicology			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Students should have basic knowledge of environmental toxicants.			
COURSE OBJECTIVES	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 the environment's fate and transport of toxicants and how these processes affect their toxicity.		
COURSE OUTCOMES (CO)	By the end of the course, students will 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 **CO3.** Inspect the routes of entry of different environmental toxicants **CO4.** Critically evaluate, discuss, explain, and present contemporary topics in environmental toxicology primary scientific literature. **CO5.** Apply the knowledge acquired for evaluating contaminant exposure and risk assessment **CO6.** Gain familiarity with the factors influencing the toxic effects of chemicals in environment		

COURE CONTENT	**Hours**
UNIT I Toxicology: Introduction, definition and scope; History; Principles of toxicology- descriptive toxicology, mechanistic toxicology, regulatory toxicology, specialized areas of toxicology	**7**
UNIT II Dose-response assessment: Dose; Response; Dose-response relationship and dose-response curves; Toxicity tests	**7**
UNIT III Toxicokinetics: Absorption - Routes of toxicants exposure, Gastro-intestinal tract, Respiratory tract, Skin, Mechanisms of trans-membrane transport; Distribution - Mechanism, Structural barriers, Storage Depots	**8**
UNIT III Biotransformation reactions – Biotransformation sites, Phase I and Phase II reactions; Excretion – Urinary, Faecal, Respiratory, Other routes of excretion	**8**
UNIT IV 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.	**8**

UNIT VI Global dispersion and circulating mechanisms of toxicants in the environment; Factors affecting toxicants action; Ecosystem influence on the fate and transport of toxicants			**7**
ASSESSMENT			
PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

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

Reference Books:

1. *Frank C. L. (2003). Basic Toxicology: Fundamentals, Target Organs, and Risk Assessment, Taylor and Francis.*
2. *Zakrzewski , S.F. (2002). Environmental Toxicology, 3rd Edition, Oxford University.*
3. *Greim, H. & Snyder, R. (2018). Toxicology and Risk Assessment - A Comprehensive Introduction, 2nd Edition. Wiley.*

e-Resources:

https://litfl.com/tox-library/resources/
https://wwwn.cdc.gov/TSp/substances/SubstanceResources.aspx
https://www.webpages.uidaho.edu/etox/lectures.htm
https://www.atsdr.cdc.gov/training/toxmanual/modules/1/lecturenotes.html

ENV504: Environmental Laboratory-III (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Environmental Laboratory-III			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Core	**Practical:** 6 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Practical: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	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. 3. Get hands-on experience with the instruments which are used for environmental sampling and analysis. 4. Learn dose response relationships and toxicity testing methods.
COURSE OUTCOMES (CO)	By the end of the course, the student will 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. **CO3** Recognize and apply environmental biotechnology approaches in treatment of organic wastes **CO4.** Apply this knowledge in production of biomaterials /biofuels and pollution control. **CO5.** Understand basic mechanisms of bioremediation. **CO6.** Develop methods for improved biological processes.

COURSE CONTENT	**Hours**
Unit I Sampling methods Practical Tips to Sampling, Sample Preparation, Media and glassware Preparation, handling instrumentation,	**8**
Unit II Various tools and techniques of environmental microbial biotechnology lab, a survey of microorganisms of water and soil	**8**
Unit III Staining of isolated microorganisms, morphological identification, isolation of DNA from bacterial cells, multiplication of DNA by PCR technique.	**8**
Unit VI Calculation of LC50, LD50, EC50, ED50, acceptable daily intake (ADI), a margin of safety, therapeutic index,	**7**
Unit V Qualitative and quantitative determination of environmental toxicants in different environmental matrices	**7**
Unit VI Toxicity test on varied plant species; Germination percentage, Germination index,	**7**

Root length, Shoot length, Fresh and dry weight.		
ASSESSMENT		
End Semester Examination	UNIT- I-VI	100% (Practical Exam + Viva Voce)
SUGGESTED READINGS		

Reference Books

1. *Walker C.H., Sibly R.M., HopkinS.P., & Peakall D.B. (2008). Principles of Ecotoxicology, 4th edition. CRC Press.*
2. *Haye's A.W. & Kruger C.L. (2014). Hayes' Principles and Methods of Toxicology, 6th edition. CRC Press.*
3. *Pepper, I.L., & Gerba, C.P. (2004). Environmental Microbiology A Laboratory Manual, 2nd edition. I.L.*
4. *Hodgson, E. A. (2004). Textbook of Modern Toxicology, 3rd Edition. John Wiley & Sons, Inc.*
5. *Evans, G. M., & Furlong, J.C. (2002). Environmental Biotechnology: Theory and Application. Wiley-Blackwell, Willey.*

ENV 505: Internship/Skill Enhancement **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Internship/Skill Enhancement			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Practical:** 6 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Practical: 03
Course Pre-requisite: Student should have completed VIII/II semester of Int. M.Sc./M.Sc. programme			
COURSE OBJECTIVES	1. Learn about environmental initiatives and activities. 2. Development of skills required for environmental analysis and monitoring. 3. Exposure to real environmental problems. 4. Assess interests and abilities in their field of studies and Explore career alternatives.		
COURSE OUTCOMES (CO)	By the end of the course, the student will 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. **CO3.** Integrate theory and practice. **CO4.** Develop work habits and attitudes necessary for employment. **CO5.** Build the record of work experience. **CO6.** Develop communication and problem solving skills.		
COURSE CONTENT			**Hours**
Visit to research laboratories/ academic institutions/industries/NGOs etc. during summer vacations (3-4 weeks). Evaluation will include report submission and presentation based on their visit and work respective laboratories/institutions/industry.			**90**
ASSESSMENT			
End Semester Examination	Project Report Submission, Presentation and Viva-Voce		

ENV507: Major Dissertation **(18 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER X & IV			
Course: Major Dissertation			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory/Practical:** 36 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory/practical: 18

Course Pre-requisite: Student should have completed IX/III semester of Int. M.Sc./M.Sc. programme.

COURSE OBJECTIVES	1. 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. 4. Learn to prepare the scientific report.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to **CO1.** Identify real existing problem and searching solutions. **CO2.** Prepare and generate the scientific report with clear findings. **CO3.** Conversion of publishable results to help in a decision support system. **CO4.** Engage in systematic research and critical review of relevant information sources. **CO5** Disseminate the output of the work for public welfare and scientific community. **CO6** Carryout independent and sustained critical investigation and evaluation of selected research findings.

COURSE CONTENT	**Hours**
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 semester with submission of dissertation thesis in prescribed format. Dissertation will be evaluated by internal and external expert members based on the presentation and viva- voce.	**540**

ASSESSMENT	
End Semester Examination	Project Report Submission, Presentation and Viva-Voce

Elective Courses I

ENV431:Soil Science (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Soil Science			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	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 of soil fertility and plant nutrition.
COURSE OUTCOMES(CO)	By the end of the course, the student will be able to **CO1.** Gain knowledge on the concepts and principles of Soil Science **CO2.** Understand the soil components and the nature of the interactions between these components. **CO3.** Describe the various minerals and organic components of soils **CO4.** Understand how changes in various quantities affect soil physical and chemical properties. **CO5.** Learn about essential nutrients, soil fertility, nutrient transformations in soil. **CO6**. Identify the impact of various soil physical, chemical and biological properties on plant growth.

COURSE CONTENT	**Hours**
UNIT I Soil forming processes; Weathering and pedogenesis; Soil profile; Soil classification systems- historical developments and modern systems of soil classification; Major soil groups of India.	**8**
UNIT II Mineralogical composition of Earth's Crust; classification; crystalline and non-crystalline clay minerals; amorphous soil constituents and other non-crystalline silicate minerals; structure, composition and properties.	**8**
UNIT III 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.	**8**
UNIT IV Chemical composition of the earth's crust and soils; Soil colloids: inorganic and organiccolloids; Ion-exchange processes; Soil air and water; Soil pH; Soil alkalinity and acidity; Saline and sodic soil.	**7**

UNIT V Soil organic matter – genesis, properties, classification, functions; humus formation & decomposition; factors influencing organic matter- natural and anthropogenic.			**7**
UNIT VI Soil fertility and soil productivity; Nutrient sources; Essential plant nutrients; NPK- sources, forms, immobilization, and mineralization; Fertilizer use efficiency.			**7**
ASSESSMENT			
PART A	Internal Assessment-I	UNIT-I	20% (Written Test)
	Internal Assessment-II	UNIT-II	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT, I-III	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Brady N.C., & Weil R.R. (2007). The Nature and Properties of Soil, 14th Edition. Pearson Education.*
2. *Kim H. Tan. (2009). Environmental Soil Science, 3rd Edition. CRC press.*
3. *Millar C.E., & Turk L.M. (2002). Fundamentals of Soil Science, 2nd edition. Biotech Books.*
4. *Mehra R.K. (2004). Textbook of Soil Science, Indian Council of Agricultural Research.*

Reference Books

1. *Indian Society of Soil Science (2002). Fundamentals of Soil Science. ISSS, New Delhi.*
2. *Rattan L. (2016). Encyclopedia of Soil Science, 3rd Edition. CRC press.*
3. *Winfried, E. H. B., Peter, S. & Stephen, N. (2018). Essentials of Soil Science: Soil Formation, Functions, Use and Classification (World Reference Base, WRB), CSIRO Publishing.*

e-Resources

https://archive.nptel.ac.in/courses/126/105/126105016/
http://ecoursesonline.iasri.res.in/course/view.php?id=125
https://www.studocu.com/row/document/university-of-eldoret/soil-chemistry/483-sos-211-lecture-note/20217811

ENV432: Agrometeorology **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years)
SEMESTER IX & III

Course: Agrometeorology

Course status	TEACHING SCHEME	EXAMINATION SCHEME	CREDITS ALLOTTED
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03

Course Pre-requisite: Student should have basic knowledge of biology and chemistry.

COURSE OBJECTIVES	1. Learn meteorological and agrometeorological observations 2. Understand the process of solar radiation and its influences on crop plants. 3. Learn meteorological hazards and their impact on crop plants and the prevailing solution. 4. Learn available agro-meteorological forecast and utilization in improving crop productivity.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Understand the meteorological observation and its specific use in agricultural purposes. **CO2.** Evaluate the solar radiation and its utilization by the crop plants. **CO3.** Conceptualize the meteorological hazards and impact on the crops as well as the preventive measure to improve the crop health. **CO4.** Forecast the agro-meteorological parameters for improving the crop yield and judicious use of the natural resources in crop productivity. **CO5.** Estimate the meteorological conditions to assess the requirements for crop productivity **CO6** Gain the information about the study site**.**

COURSE CONTENT	**Hours**
UNIT I Meaning and scope of agricultural meteorology; components of agricultural meteorology; roles and responsibilities of agricultural meteorologists; importance of meteorological parameters in agriculture; important meteorological processes to agriculture-importance of various micro environments on plant growth and development.	**8**
UNIT II Earth and its atmosphere in relation to sun and seasons; solar radiation; heat balance of earth and atmosphere; radiation in the atmosphere-energy balance; agrometeorological observations: air, surface and soil temperature, air and soil humidity, vapour pressure, wind, precipitation, sunshine, radiation intensity, El Nino, La Nina, ENSO.	**8**
UNIT III Phenology and seasonal changes of weather conditions; crop climatology-thermoperiodism, photoperiodism, thermal indices and phenology: heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; agro-climatic requirement of crops.	**8**

UNIT IV Light distribution in the plant canopy, phototropism and photoperiodism, effect of meteorological factors on photosynthesis; Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance, multiple cropping patterns for different soil climatic zones in India;; Frost and frost fighting methods, hail damage and hail modification methods, Wind damage and wind breakers.	**7**
UNIT V Risks in agricultural production, history of weather and climate as accepted risk factors in agriculture; Risks of droughts; monitoring, prediction and prevention of drought; mitigating practices.	**7**
UNIT VI Agrometeorological forecasts systems, short, medium and long-range forecasts; yield forecasts model, system stimulation its concept, application and importance, agro-met advisory services.	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Brown, D. M. (1981). Agrometeorology: J. Seemann, YI Chirkov, J. Lomas and B. Primault. Springer—Verlag Berlin—Heidelberg—New York, 1979, 324 pp., US $53.90, DM 98.00.*
2. *Bishnoi, O. P. (2007). Principles of Agricultural Meteorology. Oxford Book Co.*
3. *Lenka, D. (1998). Climate, weather and crops in India. Kalyani Publishers.*

Reference Books

1. *Smith, L.P. (1975). Methods in Agricultural Meteorology (Developments in Atmospheric Science), 3rd volume. Elsevier Science Ltd.*
2. *Mavi, H.S.., & Tupper, G. J. (2004). Agrometeorology Principles and Applications of Climate Studies in Agriculture. Haworth Press, Inc., New York/London/Oxford press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo*
3. *Rao, G. (2008). Agricultural Meteorology.PHI Learning Private Ltd.*

e-Resources

https://imdagrimet.gov.in

ENV433: Water and Wastewater Treatment (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Wastewater Treatment			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of aquatic chemistry.			

COURSE OBJECTIVES	1. Learn about available waste resources and its distribution on earth 2. Understand the science and technologies of wastewater treatment processes and operations. 3. Understand the basic design criteria and the operation of wastewater treatment facilities/plants. 4. Learn the sampling and analytical techniques required for the wastewater characterization and the monitoring of the wastewater treatment plants.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Understand water resources, components of water budget and its linkage with energy and chemical budgets. **CO2**. Acquire knowledge on the water quality standards, potential sources of pollution and their corresponding qualities **CO3.** Gain knowledge of water regulations and standards required to protect public health and ensure compliance **CO4**. Link the water quality standards with the basic objectives of wastewater treatment **CO5.** Describe the purpose and operational steps of key water treatment processes used to improve water quality **CO6.** Understand the main physical, chemical and biological processes used for wastewater treatment

COURSE CONTENT	**Hours**
UNIT I Global distribution of water resources; Precipitation; Water needs and consumption; Water resource planning and management; Water budget; National Water Policy	**6**
UNIT II Water quality, water quality standards for drinking water and wastewater, water quality indices, physic-chemical indicators, composite indicators; legislative and regulatory frameworks for water pollution control	**6**
UNIT III Major sources of wastewater; physicochemical and biological characteristics of wastewater- domestic sewage and industrial effluents	**8**
UNIT IV Treatment Technologies- pre-treatment, primary, secondary and tertiary treatment methods, sewage treatment plant (STP); effluent treatment plant (ETP)	**10**

UNIT V Aerobic treatment methods-Activated sludge, oxidation ponds, trickling filter, rotating biological contactors, Anaerobic treatment methods- UASB reactors			**10**
UNIT VI Sludge management facilities, sludge thickening, sludge digestion, Biogas generation, sludge dewatering			**5**
ASSESSMENT			
PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Tchobanoglous, G., Burton, F.L. & Stensel, H. D.(2003). Wastewater Engineering: treatment and Reuse, 4th edition. Metcalf and Eddy Inc., New York, NY: McGraw-Hill.*
2. *Qasim S.R., Motley, E.M. & Zhu.G. (2002). Water works Engineering – Planning, Design and Operation, Prentice Hall, New Delhi.*
3. *Hendricks D. (2006). Water Treatment Unit Processes – Physical and Chemical, CRC Press, New York.*
4. *Staff, M.W.H. (2005). Water Treatment: Principles and Design. 2nd edition. New York, NY: Wiley.*

Reference Books

1. *Lee C.C. & Shun dar Lin, S.D. (1999). Handbook of Environmental Engineering Calculations, Mc Graw Hill, New York.*
2. *Sedlak., D. W,. (2014). 4.0: The Past, Present, and Future of the World's Most Vital Resource, Yale University Press.*
3. *Holden,J. (2019). Water Resources- An Integrated Approach, 2nd edition. Routledge.*

e-Resources

https://nptel.ac.in/courses/105104103
https://ocw.mit.edu/courses/1-85-water-and-wastewater-treatment-engineering-spring-2006/pages/lecture-notes/
https://www.studocu.com/in/document/mahatma-gandhi-university/enviornmental-engineering/module-4-its-lecture-notes-about-wastewater-treatment/30408187

ENV434: Environmental Legislation **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years)
SEMESTER VIII & II

Course: Environmental Legislation

Course status	TEACHING SCHEME	EXAMINATION SCHEME	CREDITS ALLOTTED
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03

Course Pre-requisite: Student should have basic knowledge of biology and chemistry.

COURSE OBJECTIVES	1. Acquaint the students with the environmental issues, pollution, and control and the measures taken for its protection along with the prevailing norms. 2. Develop an understanding of the prevailing national and international provisions of environmental policies and legislations. 3. Understand the environmental legislation procedures and applicability 4. Learn environmental treaties and conventions.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Get basic knowledge of environmental law policies, its relevance, and various principles. **CO2.** Understand the environmental policies and their significance. **CO3.** Understand various acts and legislation in place and suggest solutions of the gaps in the existing policies and legislation. **CO4.** Know about Environmental treaties and conventions. **CO5.** Develop environmental ethics and its significance. **CO6.** Know the significance of various historical environmental movements.

COURSE CONTENT	**Hours**
UNIT I Origin of Environmental law; Concept of Environmental law and policy; Environment and Governance.	**7**
UNIT II Overview of International Environmental Laws; Fundamental Principles and Application of International Environmental Law; International Humanitarian Law and Environment.	**7**
UNIT III Acts, rules and regulations: 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; Electronic Waste.	**8**
UNIT IV Human Communities and the Environment: Environmental movements: Chipko,	**7**

Silent valley, Bishnois of Rajasthan. Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. Environmental communication and public awareness. Value education, individual, community, corporate social responsibility. movements related to the 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.	
UNIT V Evolution and development of international environmental laws with reference to Stockholm conference on human environment, International conventions; Value education; Movements related to environment – sacred groves, bishnoi tradition, Chipko movement, Tehri dam, Sardar sarovar, Narmada dam, Silent valley. role of NGOs; Supreme court directive on the introduction of the subject of environmental studies at different levels, the introduction of cng in public transport. compensatory afforestation.	**8**
UNIT VI 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.	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Shelton, D. & Kiss, A. C. (2005). Judicial Handbook on Environmental Law, United Nations Environment Programme.*
2. *Jaswal, P.S. & Jaswal, N. (2003). Environmental Law. Pioneer Publications, Delhi.*
3. *Tiwari, R. K. (2007). Global Environmental Policies. ABD Publishers.*
4. *Trivedy, R. K. (2004). Handbook of Environmental Laws, Guidelines, Compliance & Standards, Vol. 1 & 2 Environ – Media Karad, India.*
5. *Kuttingayloan, G. M. (2009). Conventions, Treaties and other Responses to Global Issues, Vol. 1 & 2 EOLSS Publishers Co Ltd.*
6. *Singh, G. & Singh, G. (2005). Environmental Law in India. Macmillan India.*

Reference Books

1. *Sarkar, P.K. (2012). "Environmental ethics and environmental issues." International Journal of Multidisciplinary Educational Research 1.2.*
2. *Reddy, R.V. (1997). Environmental movements in India: some reflections. FIA, 1997.Agricultural Meteorology by G.S.L.H.V. Prasad Rao: Published by –PHI Learning Private Ltd.*

e-Resources

https://www.unep.org/events/unep-event/stockholm50
Environmental Laws and Constitutional Provisions In India (legalservicesindia.com)

ENV435: Energy and Environment **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) **SEMESTER VIII & II**			
Course: Energy and Environment			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Understand the physical principles underlying Earth's energy and interaction with the environment. 2. Understand the effect of the implementation of environmental technologies and policies on sustainable energy usage. 3. Learn the broader view of energy, environment and climate change impacts. 4. Learn related global and national issues and to recognize suitable energy resources.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1**. Understand the Earth energy balance. **CO2.** Gain the knowledge about the impact of energy production on environment. **CO3.** Conservation of energy, alternate energy sources. **CO4.** Energy security and their association with environmental effects in a global and societal context. **CO5.** Determine the present energy scenario at India and as well as at global scale, **CO6.** Recognize the suitable energy production and its significance.

COURSE CONTENT	**Hours**
UNIT I Energy forms and significance; heat budget of the earth; global energy flow pattern; Global energy demand: past and current perspective; Energy demand and usage in domestic, industrial, agriculture and transportation sectors. Nature, scope and analysis of local and global impacts of energy use on the environment.	**8**
UNIT II Non-renewable resources: distribution and availability, fossil fuels-coal, oil and natural gas; Oil: formation, exploration, oil shale; Natural gas: exploration, liquefied petroleum gas, compressed natural gas; Coal: reserves, coal gasification; Environmental impacts of non renewable energy consumption; future energy options and challenges.	**8**
UNIT III Renewable resources: biomass, hydroelectric power, tidal energy, wind energy, geothermal energy, hydrogen energy; Solar: solar collectors, photovoltaics, solar ponds, solar heating system; Wave, ocean thermal, tidal energy and ocean currents; Geothermal energy; Future energy sources: Hydrogen fuels, Sustainable energy, energy from biomass; bio-diesel.	**8**

UNIT IV Energy conservation and management local to global scales; Alternate energy generation system, efficiency, utilization and assessment; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.	**7**
UNIT V Environmental implications of energy use; Energy production as driver of environmental change; energy production, transformation and utilization associated with environmental impacts; Energy over-consumption and its impact on the environment, economy, and global change.	**7**
UNIT VI 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; Current and future energy use patterns in the world and in India; alternative sources as green energy, need for energy efficiency; energy conservation and sustainability.	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III-IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Hossain, J., & Apel, M. (2014). Renewable energy integration: challenges and solutions. Springer Science & Business Media.*
2. *David E. (2007). Sustainable Energy, Opportunities and Limitations, Sustainable Energy: Opportunities and Limitations (Energy, Climate and the Environment) Publisher: Palgrave Macmillan.*
3. *Santra, S.C. (2011). Environmental Science, 3rd Edition. New Central Book Agency(P) Ltd, Kolkata, India.*

Reference Books

1. *Dell, R., & David A. J. R. (2004). Clean energy. Volume 5. Royal Society of Chemistry.*
2. *Coley, D. (2011). Energy and climate change: creating a sustainable future. John Wiley & Sons.*

e-Resources

https://mnre.gov.in/

ENV436: Forest Ecology and Management (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Forest Ecology and Management			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03

Course Pre-requisite: Students taking this course are expected to have a background in general ecology.

COURSE OBJECTIVES	1. Develop and practice "ecological thinking" toward a question or problem analyzing how different abiotic and biotic factors and processes might affectthe question/problem under investigation. 2. Understand how ecological principles work across different forest types andspatial scales. 3. Develop an ecological question to investigate with a field study – designingand carrying out data collection, analyzing the data and presenting the analysis and conclusions. 4. Make scientific arguments that are supported by data, logic and credible sources of information, improve written and oral communication skills.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Describe and explain the factors and processes (especially disturbance regimes) that regulates the structure and function of forest vegetation as wellas its variation in time and space. **CO2.** Describe and explain the interactions between soil factors, meteorological factors and forest production and dynamics. **CO3.** Describe and explain the interactions between biotic factors (animals,fungi) and forest structure and function. **CO4.** Apply common methods for inventorying forests and their woodlandvegetation. **CO5.** Plan, implement, process, compile, critically analyse and evaluate the results obtained from a forest ecological field inventory and to report the results in writing and orally. **CO6**. Describe methods in forest ecological research and critically review and analyse scientific papers in forest ecology.

COURSE CONTENT	**Hours**
UNIT I Ecosystem structure, composition, pattern, and dynamics, Plant carbon gain exercise, Plant ecophysiology, water and light.	**7**
UNIT II Climate, topography, physiography, vegetation distributions across the landscape, Primary succession, Forest structural development: Introduction, Tree mortality and gap dynamics.	**7**
UNIT III Forest disturbance ecology and disturbance adaptations, Fire Ecology, Net Primary Productivity and Carbon Storage, Long-term change in forest ecosystems,	**7**

Forest Regeneration.	
UNIT IV Introduction, definition, objectives and scope of forest mensuration, Crown measurements, Height measurements - Volume tables-definition and their classification.	**8**
UNIT V Forest inventory- definition, objectives, kinds of enumeration, Sampling, Introduction to remote sensing and its application in forestry, Use of GPS/GNSS in forest inventory, Measurement stand density, Simulation techniques, Growth and yield prediction models.	**8**
UNIT VI Principles of forest management and their applications, Objects of management, purpose and policy, demand for forest products, Production function and laws of return, Valuation techniques, ProjectPlanning, Evaluation and Analysis.	**8**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation,Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Avery, T.E. & Burkhart, H.E. (2002). Forest Measurements. McGraw-Hill.*
2. *Bardgett, R.D. & Wardle, D.A. (2010). Aboveground-belowground linkages. Oxford UniversityPress, Oxford. ISBN: 978-0-19-954688-6*
3. *Barnes, B. V., Zak, D.R., Denton, S.R. & Spurr, S.H. (1998). Forest Ecology – 4th Edition. JohnWiley and Sons, Inc. New York, NY. ISBN: 0-471-30822-6*
4. *Bettinger, P., Boston, K., Siry, J.P. & Grebner, D.L. (2009). Forest Management and Planning.Elsevier, Amsterdam.*

Reference Books

1. *Landsberg, J., & 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.*
2. *Larocque, G. R. (Edtor). (2016). Ecological forest management handbook. CRC Press, Boca Raton, FL. ISBN: 978-1-4822-4785-5.*
3. *Lucka M. & Godbold D.L. (2011). Soil Ecology in Northern Forests. Cambridge University Press, Cambridge. ISBN: 978-0-521-71421.*

e-Resources

https://environment.wsu.edu/undergraduate-studies/forest-ecology-and-management/

ENV437: Sustainable Agriculture and Environmental Practices (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER VIII & II			
Course: Sustainable Agriculture and Environmental Practices			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Understand the principles underlying sustainable agriculture and interaction with the environment. 2. Determine the effect of the implementation of environmental technologies and policies on sustainable agriculture. 3. Learn the broader view of Climate change impacts related to global and national issues. 4. Assess the environmental conventions related to sustainable agriculture.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Gain an understanding of basics of sustainable agriculture. **CO2.** Understand resource management required for the agriculture system. **CO3.** Acquaintance with the alternate energy production from the agriculture sector integrated with environmental impact. **CO4.** Develop new ideas for plant, soil and micrometeorological conditions for crop productivity, **CO5.** Assess the environmental problems caused by conventional agriculture, and alternative sustainable agriculture to combat the threat of food security. **CO6.** Learn the importance of agri-environmental policies used to agricultural production and different types of ecosystem services and biodiversity.

COURSE CONTENT	**Hours**
UNIT I Definition and concept of sustainable agriculture; effect of climate change on agricultural plant and production; threat to food security local to regional to global scales; impacts of agricultural practices on the environment and benefits of sustainable farming.	**8**
UNIT II Importance of agriculture in India; Agricultural classification of crops; Soil and climatic requirement, soil conservation methods; Fundamentals of water management for agriculture.	**8**
UNIT III Sustainable land use for agriculture, biogeochemical cycles; Soil fertility; Integrated pest management; Crop disease identification and protection; Biofertilizers.	**7**

UNIT IV Energy production in the agricultural sector, energy requirement for agriculture, land use and biofuels, efficiency, and dependency of energy sources in agroecosystems; current and future perspectives of biofuels.	**8**
UNIT V Crop improvement: Quality and productivity, plant-microbiome interaction, plant and micro-meteorological conditions interaction; Nutrient utilization and recycling; food, fuel, water, recreation and other ecosystem services.	**7**
UNIT VI Economic benefits of sustainable agriculture in crop production. Food security, agriculture for achieving sustainable development goals, green revolution, white revolution and blue revolution.	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Nagothu, U. S. (2018). Agricultural development and sustainable intensification : technology and policy challenges in the face of climate change.*
2. *Balasubramaniyan, P., & Palaniappan, S.P. (2001). Principles and Practices of Agronomy AgroBios (India)Ltd., Jodhpur. 2. Cox, G.W and Atkins, M.D.*
3. *Michael, D. A., & George, W.C. (1979). Agricultural Ecology: An Analysis of World Food Production Systems. W.H. Freeman and Company, San Francisco*
4. *Singh, G. C., Venkataraman, G., Sastry, B. & Joshi, P. (1990).Manual of Soil and Water Conservation Practices. Oxford and IBH Publishing Co., New Delhi.*

Reference Books

1. *Paroda, R. S. (2018). Reorienting Indian agriculture: challenges and opportunities. CAB International.*
2. *Parray, J.A., & Nowsheen S. (2019). Sustainable agriculture: Advances in plant metabolome and microbiome. Academic Press.*
3. *Giri, B., Prasad, R., Wu, Q., & Varma, A.(2019). Biofertilizers for Sustainable Agriculture and Environment, 2019*

e-Resources

https://www.un.org/sustainabledevelopment/hunger/
https://www.fao.org/sustainable-development-

Elective Courses II

ENV531: Geo-informatics for Forest Management			**(3 Credits)**
Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Geo-informatics for Forest Management			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Students should have basic knowledge of RS &GIS and Forestry.			

COURSE OBJECTIVES	1. To generate qualified postgraduates who can be part of professional organizationsworking in the field of Forest Management. 2. To generate a skilled post graduates who can undertake research in the field of forestBiodiversity & Wildlife conservation through geospatial technology. 3. To create awareness about the role of Remote Sensing and GIS for forest management. 4. Enable and prepare students to take an interest in the field of forest Geo- informatics for the advanced studies and with significantly frontier and newer areas.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Recognize locally-important woody species and understand their ecology, use, and potential markets, measure forest trees and products. **CO2.** Extract qualitative and quantitative forest resource data from maps, aerial photographs, and digital data sources and perform boundary surveying, forest inventory and mapping. **CO3.** Recognize and describe the methods of forest regeneration and protection, including the basic principles of wild land fire, wild land firefighting, forest health. **CO4.**Identify major health threats/hazards and forest pests. **CO5.** Proficient in Geographic Information Systems (GIS) and Global Positioning Systems (GPS) and apply those and other technologies to the protection or management of natural resources. **CO6.** Develop a professional forest management development planning.

COURSE CONTENT	**Hours**
UNIT I Forest eco-systems concepts, primary productivity, nutrient cycling, conservation of forest ecosystems.forest types in India, conventional survey.	**7**

UNIT II Remote sensing based classification of forests, spectral properties of vegetation, sampling methods, forest monitoring through remote sensing, GIS for management and modelling of forests, forest fire, firemanagement by RS & GIS.	**7**
UNIT III Role of afforestation and forest regeneration, human impacts; encroachment, poaching, grazing, shifting cultivation and control, disease and stress detection principles of conservation, needs for forest conservation.	**7**
UNIT IV Advances in RS & GIS techniques for forest conservation & management using LiDAR, SAR andhyperspectral data.	**8**

UNIT V

Digital Photogrammetric Images from UAV and associated concepts, UAV flight planning, coveragetypes, processing methods. Recent trends in its applications.

UNIT VI

Present global status of forests, distribution and its contribution as natural resources, over-exploitation:deforestation and its societal impact, forest products, developing and developed world strategies for forestry, climate change impacts on forests and their assessment.

ASSESSMENT

PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation,Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Srinivas, M.G. (2001). Remote Sensing Applications, Narosa Publishing House, New Delhi.*
2. *Andrew, R. (1999). Manual of Remote Sensing. Volume 3, 3rd edition. Remote Sensing for the Earth Sciences, American Society for Photogrammetry and Remote Sensing, John Wiley and Sons, New York.*
3. *Steven, E. F. (2001). Remote Sensing for Sustainable Forest Management.CRC Press.*

Reference Books

1. *Jensen, J.R. (2001). Remote Sensing of the Environment – An Earth Resource Perspective. DorlingKindersley (India) Pvt. Ltd., New Delhi.*
2. *Agarwal, C.S. & Garg, P.K. (2000). Textbook on Remote Sensing in Natural Resources Monitoring andManagement. Wheeler Publishing, New Delhi.*
3. *Narayan, L.R.A. (2001). Remote Sensing and its Applications. Universities Press (India) Ltd.,Hyderabad,2001.*

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http://www.itc.nl/~bakker/rs.html
www.ccrs.nrcan.gc.ca/resource/tutor/fundam/index_e.php
rst.gsfc.nasa.gov/http://www.r-s-c-c.org/rscc/v1m1.html
www.isprs.org www.spaceimaging.comwww.landsat.usgs.gov.inwww.nrsa.gov.in
http://www.euromap.de/ http://www.nrsa.gov.in/

ENV532: Occupational Hazards **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Occupational Hazards			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of toxicology.			

COURSE OBJECTIVES	1. Understanding of the relatedness of occupations and public health. 2. Learn about health hazards in varied occupations. 3. Understand legislative requirements, industry standards, and best practices in a variety of workplaces. 4. Impart knowledge on various concepts of prevention/protection to occupational Health and safety mechanisms.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to **CO1.** Describe the major components and elements of the occupational health and safety; **CO2.** Relate health protection concepts to the occupational health and safety program. **CO3.** Identify the ways in which physical, chemical and other hazardous agents in the work environment can affect human health. **CO4.** Acquire knowledge of the types of diseases which can arise from work **CO5.** Learn how scientific method and epidemiology can be applied in disease recognition **CO6.** Apply different prevention and control measures to ensure safety against occupational hazards

COURSE CONTENT	**Hours**
UNIT I History of concept, Recognition and evaluation of health hazards Organizational factors, Human factors.	**6**
UNIT II 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.	**8**
UNIT III Psychosocial hazards; Physical safety hazards; Ergonomic hazards; Work organization hazards	**8**
UNIT IV Occupational diseases-Pneumoconiosis, Silicosis, Anthracosis, Byssinosis, Bagasosis, Asbestosis, Farmer's lung, Metal poisoning, Occupational cancer, Occupational dermatitis, Radiation Hazards.	**11**

UNIT V Occupational health; Safety and health programmes, core elements; Occupational Safety and Health Act (OSHA); Occupational exposure limits.	**6**
UNIT VI 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)	**6**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I	20% (Written Test)
	Internal Assessment-II	UNIT-II	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT, I-III	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Haldar, S.K. (2017). Industrial and Occupational Health, CBS Publishers & Distributors..*
2. *Benjamin O. A. (2008). Fundamental Principles of Occupational Health and Safety, International Labour Office; 2nd edition.*
3. *Barry, S. L., David, H.W., Sherry, L.B. & Rosemary, K.S. (2011). Occupational and Environmental Health: Recognizing and Preventing Disease and Injury 6th Edition, Oxford University Press.*

Reference Books

1. *Burgess, W.A. (1995). Recognition of Health Hazards in Industries: A Review of Materials and Processes. 2nd Edition. New York, NY: John Wiley and Sons, Inc.*
2. *Wald, P. & Gregg, M.S. (2001). Physical and Biological Hazards in the Workplace. New York, NY: Van Nostrand Reinhold.*
3. *Dinardi, S. (2003). The Occupational Environment Its Evaluation and Control. 2nd Ed. Fairfax, VA: American Industrial Hygiene Association.*

e-Resources

https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes/env_occupational_health_students/ln_occ_health_safety_final.pdf
https://www.cdc.gov/niosh/docs/2004-101/pdfs/OccupDis.pdf
https://www.osti.gov/servlets/purl/7278484

ENV 533: Aquatic and Chemical Ecology **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Aquatic and Chemical Ecology			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have significant knowledge of Ecology, Environmental Science and Life Science.			
COURSE OBJECTIVES	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. 4. Upgrade and advance knowledge in ecology.		
COURSE OUTCOMES (CO)	By the end of the course the student will be able to: **CO1.** Understand the concepts of aquatic microbial ecology and chemical ecology **CO2.** Improve and upgrade their knowledge in ecology and environment **CO3.** Identify the fundamental questions in aquatic and chemical ecology **CO4.** Analyse nature of biotic interactions with a special prospect on microbial and chemically mediated communications in nature. **CO5**. Analyse and evaluate the characteristics of aquatic ecology, role of aquatic microbes and chemical ecology. **CO6.** Develop and create independent thinking for understanding the nature of biotic interactions and chemical communications.		

COURSE CONTENT	**Hours**
UNIT I Introduction and scope of chemical ecology, the ecology of chemical defences, chemical communication, and biosynthesis of cues. Chemical signals/allelochemicals and environmental cues, chemical signals for resources and transport.	**7**
UNIT II Pheromones, allelopathy, Examples of chemical ecology on the context of social behavior, community structure and population dynamics. Quorum sensing in bacteria.	**8**
UNIT III Introduction of aquatic microbial ecology, Microbiomes, Volatile Sulfur and Organic carbon emission by microbial processes.	**7**
UNIT IV Role of viruses, autotrophic and heterotrophic bacteria in the dynamics of community structure and nutrients' assimilation.	**7**
UNIT V Regulation of nutrients and trace metal mobility in aquatic system. Advanced methods in trace metal biogeochemistry and microbial diversity.	**7**

<table>
<tr><td colspan="4">UNIT VI
Distinction in ecology of fresh, brackish, estuarine and marine environments. Ecological issues related to processes and structures at different integration levels. Harmful algal blooms and stressed environment. Coral reef dynamics</td><td>8</td></tr>
<tr><td colspan="5">ASSESSMENT</td></tr>
<tr><td rowspan="2">PART A</td><td>Internal Assessment-I</td><td>UNIT- I, II</td><td colspan="2">20% (Written Test)</td></tr>
<tr><td>Internal Assessment-II</td><td>UNIT- III, IV</td><td colspan="2">20% (Marks in any mode: Assignment Presentation, Quiz)</td></tr>
<tr><td>PART B</td><td>End Semester Examination</td><td>UNIT- I-VI</td><td colspan="2">60% (Written Test)</td></tr>
<tr><td colspan="5">SUGGESTED READINGS</td></tr>
<tr><td colspan="5">Text Books:
1. Thomas E. & Jerrold, M. (1995). Chemical Ecology: The Chemistry of Biotic Interaction. S, for the National Academy of Sciences.
2. Bagnères, A.G. (2016). Martine Hossaert-McKey, Chemical ecology London, UK: ISTE Ltd; Hoboken, NJ, USA: John Wiley & Sons, Inc.,
3. Barnes, R.S.K., & Mann, K. H. (1992). Fundamentals of Aquatic Ecology, John Wiley & Sons.
4. Ragothaman, G., & Trivedy, R.K. (2010). Aquatic Ecology: A Text Book. EM International.
Reference Books:
1. Roland, M., & Bartha, R. (1987). Microbial ecology: fundamentals and applications. Atlas, The Benjamim. Cummings Publ., Menlo Park.
2. Barton, L.L., & Mclean, R.J.C. (2019). Environmental Microbiology and Microbial Ecology. John Wiley & Sons.</td></tr>
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ENV534: Glaciology and Glacial Processes (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Glaciology and Glacial Processes			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of geosciences.			

COURSE OBJECTIVES	1. Conceptualization of glaciers, glaciological features and their global importance. 2. Understanding of the energy budget process of the glacier. 3. Understanding glaciological measurements. 4. Knowledge of glaciological hazards like GLOF.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1.** Gain basic physical principles in glaciology and the concept of glaciers, their types, characteristics, and importance. **CO2.** Understand the glacier, its formation and glaciological features. **CO3.** Assess the energy balance of glaciers and understand its impact on glacial melting processes. **CO4**. Understand the impact of climate on glacier mass balance, movement and extent through indirect and direct feedback mechanisms. **CO5.** Explain and examine glaciological methods used in the research today **CO6.** Understand how today's glaciers in various regions are getting affected and shall be affected by climate variability and its impact as a glaciological hazard.

COURSE CONTENT	**Hours**
UNIT I 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	**8**
UNIT II 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	**8**
UNIT III Radiation: Shortwave and longwave radiation, Net radiation, Albedo. Temperature: Surface and subsurface, cold content of snow and ice. Relative humidity, atmospheric pressure and wind. Turbulent fluxes: Sensible and latent heat flux, ground heat flux. Surface Energy Budget. The energy available for melting and modelling the melt	**8**

UNIT IV Mass balance of a glacier and related terms (e.g. ELA, AAR, mass balance gradient), Methods: Direct glaciological method, Geodetic Method, Hydrological Method, Temperature Index Model, Linear Mass Balance Model, Energy Mass Balance Model	**7**
UNIT V Snow and Glacier runoff model in Himalaya, Water balance of a glacierized catchment, contribution of melt to stream flow, impact of Climate Change on Water Resources. Discharge measurement methods: Runoff measurements, water level measurements, area velocity method, current meter, velocity sensor, tracer methods. Sediment load study in a glacierized terrain.	**7**
UNIT VI 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	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Paterson, W. S. B. (1969). The Physics of Glaciers, 3rd Edition. Perganon Press, Oxford, London, Edinburg.*
2. *Alen, M. H. J. (1992), Glaciers, Cambridge University.*
3. *Douglass I. B. & Davis, J. A. E. (1998). Glacier and Glaciation, Dept. of Geography and Topo Science, University of Glasgow, UK.*

Reference Books:

1. *Nakawo, M. & Hayakawa, N. (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.*
2. *Oerlemans, J. (1989). Glacier Fluctuations and Climatic Change. Kluwer (Dordrecht), 417 pp.*
3. *Parry, J. L., & Tranter, M. (2012). The Ecology of Snow and Ice Environments Oxford University Press.*
4. *Martinek, J., Rango, A., & Roberts, R. (2008). Snowmelt Runoff Model (SRM) User's Manual.*

ENV535: Environmental Stress on Vegetation **(3 Credits)**

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Environmental Stress on Vegetation			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of biology and chemistry.			

COURSE OBJECTIVES	1. Understand the various environmental stresses and effects on plants. 2. Learn the effect of environmental stresses as limiting factors in plant growth, development, productivity, and plant biodiversity. 3. Understand the physiology and biochemistry of plants 4. Understand the adaptation strategies of plants under stress.
COURSE OUTCOMES (CO)	By the end of the course, the student will be able to: **CO1**.Students would be able to correlate environmental stress and effects on vegetation. **CO2.** The students will understand Physiological and biochemical mechanisms in plants altered due to environmental stress. **CO3.** Utilization of knowledge for bio monitoring mechanisms and adaptive mechanisms. **CO4**. Acquire knowledge about the environmental stress from plant to community level. **CO5.** Understand the adaptation strategies of plants against environmental stress. **CO6.** Understand about the bio-indication of the environmental stress.

COURSE CONTENT	**Hours**
UNIT I Natural and anthropogenic source of environmental stresses: Abiotic stress: radiation, salinity, floods, drought, heat and light, cold and freezing, heavy metals, environmental pollution; Biotic stresses- pathogens, fungi, bacteria, oomycetes, nematodes and herbivores.	**7**
UNIT II The environment of plants: Climatic, seasonal and diurnal trends including extremes in weather such as temperatures, radiation (global and photosynthetically active radiation, diffuse radiation including reflectance from soil, canopies and leaves), rainfall, atmospheric carbon dioxide, minerals, and others such as ozone and UV-B radiation etc.	**8**
UNIT III Photosynthetic mechanisms and principles affected by environmental factors, photosynthetic responses to a range of temperature, rainfall (irrigation), light intensity, ultraviolet-B radiation, carbon dioxide concentration, and mineral nutrition; Cellular and biochemical mechanisms relate to plant responses to the environment.	**8**
UNIT IV Plant responses from leaf physiological processes to canopies and finally to community, growth and developmental processes with environmental factors inter and intra-plant and the overall community-level productivity.	**7**

UNIT V Biotic and abiotic stresses affect plant growth, development and crop productivity; Adaptation strategies at the morphological and anatomical level of plants, signal transduction, phytohormones.			**8**
UNIT VI 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.			**7**
ASSESSMENT			
PART A	Internal Assessment-I	UNIT- I, II	20% (Written Test)
	Internal Assessment-II	UNIT- III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I-VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Lincoln, T. L., & Zeiger, E. (2012). Plant Physiology, 5th Edition.*
2. *Buchanan, B.B., & Gruissem, W., & Russell, L. (2015). Biochemistry and Molecular Biology of Plants, 2nd Edition.*
3. *Dey, P.M. & Harborne, J.B. (1997). Plant Biochemistry. Academic Press.*

Reference Books

1. *Shah, F. (2021). Abiotic stress in plants. BoD–Books on Demand.*
2. *Gerhardt, A. (2019). Bioindicator species and their use in biomonitoring. Environmental monitoring 1 (2002): 77-123. Bosco de Oliveira, Alexandre. "Abiotic and Biotic Stress in Plants." 174.*
3. *Wood, W. B. (2001). ENVIRONMENTAL CHANGE AND MIGRATION, Global migrants, global refugees: Problems and solutions ,42.*

ENV 536: Carbon Capture and Sequestration Technology (3 Credits)

Program: Environmental Science Integrated M.Sc. (5 years) & M.Sc. (2 years) SEMESTER IX & III			
Course: Carbon Capture and Sequestration Technology			
Course status	**TEACHING SCHEME**	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Elective	**Theory:** 3 hours/week	**Internal Assessment:** 40 Marks **End Semester Exam:** 60 Marks	Theory: 03
Course Pre-requisite: Student should have basic knowledge of Ecology, Environmental Science and Life Science.			

COURSE OBJECTIVES	1. Understand the carbon concentrating mechanisms and global carbon cycling in the context of climate change mitigation and the significance of carbon capture technologies 2. Give 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. 4. Analyze available methods CCS to combat climate change.
COURSE OUTCOMES(CO)	By the end of the course, the student will be able to: **CO1.**Understand how carbon is regulated in different environmental components. **CO2.** Understand how carbon capture and sequestration/storage (CCS) fits into the energy space. **CO3.** Evaluate the biological carbon capture and physico-geo-chemical sequestration procedures. **CO4.** Distinguish carbon concentrating mechanisms in the biological world. **CO5.** Analyze appropriate and available methods of CCS to integrate it with the green technologies. **CO6.** Judge the appropriate methods of carbon capture and sequestration.

COURSE CONTENT	**Hours**
UNIT I Introduction and scope of the CCS (Carbon capture and sequestration). CCS in the energy space- A nexus between energy, electricity, fossil fuel and carbon emission, Carbon budget of the Earth, Carbon emissions.	**8**
UNIT II Sequestration in different environmental segments, atmospheric, trends of historic CO_2 levels and global changes in carbon, limitations of the natural carbon sequestration. Carbon concentrating mechanisms of plants and algae.	**8**
UNIT III 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.	**8**
UNIT IV Membranes- physical and chemical factors affecting the potential membranes for carbon sorption and transformation. Artificial photosynthesis. Merits and demerits of	**7**

the different methods.	
UNIT V Geotechnology for CCS**.** Geologic Carbon Sequestration: Introduction, Continuum Scale, Pore-Scale Phenomena, selection of CO_2 storage sites, additional economical processes e.g enhanced oil recovery.	**7**
UNIT VI Carbon sequestration using deep natural minerals, saline lands, lagoons, the process of CO_2 injection and transportation, sorption and sequestration mechanisms. CO_2 sequestration in seawater and saline reservoirs. Carbon sequestration in soil. Biotechnology for improvement in biological sequestration.	**7**

ASSESSMENT

PART A	Internal Assessment-I	UNIT-I, II	20% (Written Test)
	Internal Assessment-II	UNIT-III, IV	20% (Marks in any mode: Assignment Presentation, Quiz)
PART B	End Semester Examination	UNIT- I- VI	60% (Written Test)

SUGGESTED READINGS

Text Books:

1. *Baird, C., & Cann, M. (2008). Environmental Chemistry, W.H. Freeman and company.*
2. *Manahan, S. (2017). Environmental chemistry. CRC press.*

References:

1. *Rackley, S. A. (2017). Carbon Capture and Storage, 2nd edition. Butterworth- Heinemann – Elsevier.*
2. *Jennifer, W. (2012). Carbon Capture, Springer.*
3. *Hester, R.E., & Harrison , R.M. (2010) .Carbon capture: sequestration and storage. Royal Society of Chemistry.*
4. *Borowitzka, M.A., Beardall, J. & Raven, J.A. (2016). The physiology of microalgae (Vol. Cham: Springer).*