GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

Guru Gobind Singh Indraprastha University
Sector – 16C Dwarka, New Delhi – 110078

(Coordination Branch)
Ph:011-25302135-136, Email: coordination112@gmail.com, Website: www.ipu.ac.in

F.No.: GGSIPU/Co-ord./50th AC/2021/ 121 **Dated:** 2nd **July, 2021**

Circular

Please find enclosed herewith the final Minutes of the 50th meeting of the Academic Council of the Guru Gobind Singh Indraprastha University held on **11/06/2021 at 11:00 AM** on Cisco Webex platform.

Ravi Dadhich

(Ravi Dadhich)
Registrar

To,

1 Dean- USBAS/ USBT/ USCT/ USEM/ USICT/ USHSS/ USMC/ USLLS/ USM&PMHS/ USMS/ USAP/ USE, GGSIP University.
2 Director- Academic Affairs/ Coordination/ Students' Welfare/ CDMS/ Development/ International Affairs/ CEPS/ Research and Consultancy/ Legal Aid / IUIIC, GGSIP University
3 Librarian, GGSIP University
4 Prof. P.K. Jhulka, (Retired), Max Institute of Cancer Care, 26-A Ring Road, Nirmal Puri, Nirmal Colony, Block -2, Lajpat Nagar-IV, New Delhi-110024
5 Prof. M.C. Sharma, 109, Nav Shakti Sadan, Sector 13, Rohini, New Delhi-110085
6 Prof. Karmeshu, (Retired), 150, Deepali, Road No. 42, Pitampura, Delhi-110034
7 Sh. Arvind Misra, 5/101, Mathura Road, Agra-282002
8 Shri. Sandeep Gupta, 100 UB Jawahar Nagar, Delhi-110007
9 Prof. Rajiv Bhat, School of Biotechnology, Jawaharlal Nehru University, New Delhi
10 Prof. (Dr.) Pradeep Kulshrestha, Dean, School of Law, Sharda University, Plot No. 32 & 34, Knowledge Part-III, Greater Noida-201306 (UP)
11 Ar. Rupal S. Randhawa, 204-A, Pocket B, Mayur Vihar, P hase-2, New Delhi-110091
12 Dr. Jagdish Lal Gupta, CP-18, Maurya Enclave, Pitam Pura, Delhi-110034.
13 Prof. M. Afzal Wani, University School of Law and Legal Studies, GGSIP University
14 Prof. Prodyut Bhattacharya, University School of Environment Management, GGSIP University
15 Prof. Amit Prakash Singh, University School of Information Communication & Technology, GGSIP University
16 Prof. Shalini Garg, University School of Management Studies, GGSIP University.
17 Prof. Lisa P. Lukose, University School of Law and Legal Studies, GGSIP University.
18 Prof. M.N. Hoda, Director, Bharti Vidhyapeeth's Institute of Computer Application & Management, A-4, Paschim Vihar, Rohtak Road, New Delhi-63.
19 Prof. Sonia Jindal, Principal, Gitarattan Institute of Advanced Studies and Training, Rohini, Delhi-85.
20 Prof. Ravi K. Dhar, Director, Jagannath International Management School, OCF, Pocket-9, Sector-B, Vasant Kunj, New Delhi-110070.
21 Prof. Maharaj Krishen Bhat, Director, Maharaja Agrasen Institute of Management Studies, Maharaja Agrasen Camp, Plot No. 1, Sec-22, Rohini, Delhi.

Copy for information of the Competent Authority:

(i) AR to the Vice Chancellor Secretariat for kind information of Hon'ble Vice Chancellor, GGSIP University.
(ii) AR to the Registrar office for information of Registrar, GGSIP University

(Shikha Agarwal)
Dy. Registrar (Coordination)

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
SECTOR – 16 C, DWARKA, NEW DELHI - 110078

GURU GOBIND SINGH
INDRAPRASTHA
UNIVERSITY

FIFTIETH (50th) MEETING OF THE ACADEMIC COUNCIL

DATE : 11.06.2021

TIME : 11:00 AM

MINUTES OF 50th MEETING OF THE ACADEMIC COUNCIL

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21	AC 50.21	To ratify the recommendations of the subcommittee of Academic Council by Hon'ble Vice Chancellor to consider the case of detention of Two (02) students of 3rd year of batch 2017 of Ch. Brahm Prakash Govt. Engineering College (CBPGEC)	10
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change in the duration of the MCA programme from 3 years to 2 years w.e.f. Academic Session 2020-2021.

Agenda Item No. AC 50.27: **To ratify the Scheme & Syllabus of Ph.D. course work at USIC&T for the Academic Session 2020-2021 onwards.**

The Academic Council ratified the Scheme & Syllabus of Ph.D. course work at USIC&T w.e.f. Academic Session 2020-2021.

Agenda Item No. AC 50.28: **Change in nomenclature of PhD degree offered by USEM from Ph.D. in Environment Management to Ph.D. in Environmental Science**

The Academic Council considered and approved the change in nomenclature of Ph.D. degree offered by USEM from Ph.D. in Environment Management to Ph.D. in Environmental Science.

Agenda Item No. AC 50.29: **Revised Scheme of Examination and Syllabus of M.Sc. Environment Management as per the LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF)**

The Academic Council considered and approved the Revised Scheme of Examination and Syllabus of M.Sc. Environment Management as per the LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF) w.e.f. Academic Session 2021-22.

Agenda Item No. AC 50.30: **Revised Scheme of Examination and Syllabus of M.Sc. Biodiversity and Conservation as per the LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF)**

The Academic Council considered and approved the Revised Scheme of Examination and Syllabus of M.Sc. Biodiversity and Conservation as per the LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF) w.e.f. Academic Session 2021-22.

Agenda Item No. AC 50.31: **Revised Scheme of Examination and Syllabus of M.Sc. Natural Resource Management as per the LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF)**

The Academic Council considered and approved the Revised Scheme of Examination and Syllabus of M.Sc. Natural Resource Management as per the LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF) w.e.f. Academic Session 2021-22.

Agenda Item No. AC 50.32: **Syllabus, Course code and credits of the course Environmental Studies (as proposed by the UGC and AICTE) to be offered to all the**

SCHEME OF EXAMINATION

and

SYLLABUS

of

MASTER OF SCIENCE

ENVIRONMENT MANAGEMENT

(Programme Code: 047)

For

Academic Session 2021 - Onwards

Based on

LOCF (Learning Outcome Based Curriculum Framework)

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
Sector 16C, Dwarka
New Delhi 110078

Enterpreneurship | Employbility | Skill Development

Approved in the 50th Academic Council meeting held on 11th June, 2021 w.e.f. AS 2021-22 vide Agenda item 50.29.

Programme Code: **047**

Title of the Programme: **Master of Science (Environment Management)**
(Restructured Curriculum implemented from August 2021batch)

University School of Studies of the Programme: University School of Environment Management (USEM)

Contact for any further query:
Dean's Secretariat USEM
Ph: 91-11-25302360/62

Issued from

The Office of the Director, Academic Affairs
GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
Sector 16C, Dwarka
New Delhi- 110078 (India)

w.e.f. Academic Session 2021 Onwards

Master of Environment Management
(M.Sc. Programme)

The M.Sc. course of Environment Management under the University School of Environment Management School addresses future environmental problem and sustainable use of natural resources through quality education, training and research. The vision of the programme is to actively pursue the goals of imparting quality education, training and facilitate research in the field of environment and also act as a think tank in policy matters related to environment management and sustainable development. The programme is set up for the accomplishment of its nation to build a pool of trained and dedicated professionals who can contribute to the systematic development of policies, measures and programmes for environment management and sustainable development at national and international levels. The vision of the course is to tackle the problems faced by the society and humankind due to gradual and ever increasing depletion of Earth's limited resources and existing method of their use which leads to increasing pollution and destruction of Environment. The mission of the programme is to find the solutions to variety of environmental related problems and to train professionals for future generations to handle them effectively.

The programme offers excellent employability with our alumni at various government & non-government organizations, industries, consultation farms, projects and fully funded Ph.D positions in various national and international universities.

The programme objectives are:

- To provide quality education and training in environment management.
- To pursue and facilitate contemporary research in various facets of bioresources and environment using modern analytical and other tools such as geospatial techniques.
- To establish working linkages with industry and undertake research on environment related issues.
- To foster environmental awareness and promote the principles and practices of sustainable development.

Programme Outcomes (PO)

- PO_1:To provide quality education and training in environment management.
- PO_2:To pursue and facilitate contemporary research in various facets of bio-resources and environment using modern analytical and other tools such as geospatial techniques.
- PO_3: To establish working linkages with industry and undertake research on environment related issues.
- PO_4:To foster environmental awareness and promote the principles and practices of sustainable development.

Programme Specific Outcomes (PSOs)

- PSO_1: To provide in-depth and comprehensive knowledge about ecosystem functions, services, pollution management, environmental impact assessment, restoration, climate change, environmental policies and regulation.
- PSO_2: To train the students as environmental professionals well-equipped to work in different sectors like industry, developmental projects as EIA professionals, climate change mitigation, energy technologies, pollution and health safety, areas of ecosystem integrity and biological remediation.

Choice-Based Credit System

University follows Credit System of syllabi and examination. UGC has recently given guidelines for choice-based credit system with a defined nomenclature for designing scheme of examinations and syllabus of different courses. In view of this, Scheme of Examinations and Syllabus have been revised and framed in accordance with the new UGC Guidelines and the courses have been divided into the following categories:

a. Foundation Course
b. Value based foundation course
c. Generic/Core Elective (GE)
d. Open Electives (OE)

Students have been given wide choice in selection of Generic Elective and Open Elective. A student may choose open elective either from the open electives floated by the School or may opt from the open electives offered by other University School of Studies. However, Generic/Core Elective is to be chosen from the Generic Elective Courses offered by the University School of Environment Management.

Examination

The University has adopted the semester system for this programme. In addition to the End Term Examination, there is a continuous evaluation of student's performance throughout the academic programme. The Odd Semester Examinations are conducted in the months of December-January and the Even Semester Examinations are conducted in the months of May-June every year.

Industrial and Field Visits, Summer Training and Dissertations

The syllabus covers enough field exposure to students for the interactions with outside world through educational field excursions, summer training and dissertations. All these components are evaluative and supervised by experienced faculty members. In the process students can get first hand and practical knowledge through such activities for which credit weightages are given in the scheme.

Evaluation and Award of Degree

The overall weightage of a course in the syllabi and Scheme of Examination is determined in terms of credits assigned to the course. Obtaining a minimum of 50% marks in aggregate in each course including the End Term Examination and teacher's continuous evaluation is essential to earn the assigned credits. A student who secures less than 50% of marks in a course is, therefore, deemed

to have failed in that course. A student is eligible for the award of University degree, if he/she has registered himself/herself, has undergone the regular course of studies, completed the project report/dissertation specified in the curriculum of his/her programme within the stipulated time, and has secured the minimum number of credits as prescribed for the award of concerned degree.

Broad Guidelines for Question Paper

The question papers are key tools in assessing student learning process. Question papers are very meticulously planned so as to spread over the entire syllabus and possibly imbibe all components of assessment such as:

1. Knowledge
2. Comprehension
3. Application
4. Analysis & Evaluation
5. Synthesis
6. Creativity & Innovation

Instructions to Paper Setter

1. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
2. Apart from the question no.1 rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. Student will have to attempt only 1 question from each unit. Each question will carry equal marks.

Summer Training

1. After 2nd semester students will undergo summer training for six weeks in different industries/institutes.
2. The summer training reports will be evaluated in two parts. The Corporate Executive, under whose guidance the summer training project has been completed, shall award marks out of 50. An internal Board of Examiners will evaluate the work for 50 marks recommended by the Dean.
3. Evaluation will be based on the report and their presentations in the presence of the faculty members of the School.

Dissertation

1. Each student shall carry out a study for dissertation in the 4th Semester either in a research institution and or Govt./Private Organization that specializes in area relevant to the broad area of Environment Management or in-house at USEM.
2. The student will submit a synopsis at the beginning of the semester for approval from the department committee in a specified format. The student will have to present the progress of the work through seminars and progress reports. Evaluation of dissertation will be based on thesis and viva/voce by the Board of Examiners comprising the External Expert & Internal Examiner.

Credit Requirement

1. The student will require to earn a minimum of 100 credits for the award of the degree (Ref. GGSIPU/SMS/2000/1850, minutes of the joint Meeting of the Curriculum Development Committee)
2. The student will not have the option to drop any course covered in the scheme of examination. He/she will be required to register for all the courses listed in the scheme of examination.

Master of Environment Management
(M.Sc. Programme)

TEACHING METHODOLOGY AND SYSTEM OF INTERNAL ASSESSMENT FOR THEORY

Pedagogy to be followed

1. Lectures
2. Individual Assignments/ Group Assignments
3. Field/ Industry/ Internet-Based Project
4. Case Studies
5. Role Plays
6. Quizzes
7. Video Lessons

System of Internal Assessments:

1.	Attendance and Assignments:	05 Marks
2.	Mid-Term Examination:	20 Marks
	Total Marks	**25 Marks**

Note: Internal assessment will continue till the time System of Continuous Evaluation is not implemented in the program by the University.

Note:

In case the programme is of 02 years duration then 4 semesters will be there,

MASTER OF ENVIRONMENT MANAGEMENT
M.Sc. (EM)

Code No.	Subject	L	T	P	Credits
First Semester					
EM 601 FoundationCourse	Fundamentals of Ecology, Biodiversity and SustainableDevelopment	**4**			**4**
EM 603	Environmental Chemistry	**3**			**3**
EM 605	Environmental Geosciences & Natural Disasters	**3**			**3**
EM 607	Fundamentals of Geoinformatics	**4**			**4**
EM 609	Energy Resources and Technology	**4**			**4**
EM 611	Environmental Statistics	**3**			**3**
EM 613	Seminar/Term Paper *	**1**			**1**
Practicals					
EM 651	Geoinformatics Lab			**4**	**2**
EM 653	Environmental Chemistry and Energy Lab			**4**	**2**
EM 655	Environmental Statistics and Computer Application Lab			**4**	**2**
	Semester Credit				**28**
Second Semester					
EM 602	Air Pollution, Meteorology and Control	**4**			**4**
EM 604	Water Pollution and Waste Water Treatment	**4**			**4**
EM 606	Basic and Applied Environmental Microbiology	**4**			**4**
EM 608	Solid and Hazardous Waste Management	**3**			**3**
EM 610 Value basedcourse	Environmental Policies, Ethics and Legislation	**3**			**3**
HVE 102 (NUES)	Human Values and Ethics				**2**
	Generic/ Core Elective (Any One)				
EMGE 616	Environmental Modelling	**4**			**4**
EMGE 618	Ecotechnology for Environment Management	**4**			**4**
EMGE 620	Environmental Biotechnology	**4**			**4**
EMGE 622	Aquatic Ecosystems and Wetland Management	**4**			**4**
EMGE 624	Geospatial Technology for Environment Management	**4**			**4**
EMGE 626	Watershed Management	**4**			**4**
EMGE 628	Essentials of Urban Forestry and Biodiversity	**4**			**4**
Practicals					
EM 652	Environmental Microbiology Lab			**4**	**2**
EM 654	Air and Water Pollution Lab			**4**	**2**
EM 656	Field Visit/Industry Visit – Report/Presentation				**2**
	Semester Credit				**30**
Summer Training (6-8 Weeks) *					
Third Semester					
EM 701	Environmental Impact Assessment & Risk Analysis	**4**			**4**
EM703	Ecosystem Management and Restoration	**4**			**4**
EM 705	Industrial Pollution Prevention and Control	**3**			**3**
EM 707	Environmental Health and Safety	**3**			**3**
EM 709	Environmental Instrumentation	**3**			**3**
USMS 112NUES)	Entrepreneurial Mindset				**2**

Practicals					
EM 751	Ecology and Ecosystem Restoration Lab			**4**	**2**
EM 753	Environmental Instrumentation Lab			**4**	**2**
* NUES (Non – University Examination System)					
EM-755	Summer Training Report & Présentation				**2**
Open-Electives (Any one) **					
EMOE 731	Climate Change Mitigation & Adaptation	**4**			**4**
EMOE 733	Disaster Risk Reduction and Management	**4**			**4**
EMOE 735	Urban Biodiversity Strategies for Conservation	**4**			**4**
EMOE 737	Human Aspects of Biodiversity and Environment	**4**			**4**
EMOE 739	Sustainable Ecotourism	**4**			**4**
	Semester Credit				**29**

Fourth Semester - Dissertation					
EM 752	Dissertation Based Seminar and Progress Report				**4**
EM 754	Dissertation and Viva Voce				**22**
	Semester Credit				**26**
	Total Credits				**113**

Total number of credits offered in all four semesters is 113

- Summer Training (6-8 weeks) will be conducted outside University in any industry/organization at the end of second semester during summer vacation. This will be evaluated in 3rd semester in NUES mode.
- Students will opt for one relevant open elective paper offered by USEM or by any other University School of Studies of GGSIPU.
- Educational/ Industrial field visit will be conducted in 2nd semester, which is compulsory and evaluated in NUES mode.

FIRST SEMESTER

Course Code: FUNDAMENTALS OF ECOLOGY, BIODIVERSITY AND SUSTAINABLE DEVELOPMENT

Course Code: EM 601 L-04 Credits – 04

Course Objectives:

CO_1	To understand the basics of Ecology, ecological concepts and the ecosystem.
CO_2	To understand the importance of biodiversity and its conservation approaches.
CO_3	To understand the global ecological issue and challenges to human ecology.
CO_4	To understand the concept of sustainability and components of sustainable development.

UNIT I Ecology and Ecosystem 12 Hrs.

- **Ecology:** Definition and scope of ecology, types of ecosystem, abiotic and biotic environments, biotic – abiotic interactions, soil formation, soil types, USDA scheme of soil classification and soil degradation.
- **Population ecology:** Population attributes, population changes, survivorship curves, growth models, demographic models, dispersion
- **Community ecology:** Community structure, two-species interactions, food webs, Ecological succession and process of succession in different ecosystems
- **Ecosystems ecology:** Ecosystem organisation and processes, energy flows, nutrient cycling, hydrological cycling, cycling index

UNIT II Biodiversity and Biogeography 12 Hrs.

- **Biodiversity**: origin of new species; species, community and ecosystem diversity, genetic diversity; biological classification – phylogenetic relationships; classifying and naming species; Typology of species- endemic, native, exotic, invasive; Biodiversity hotspots, biodiversity and livelihood, threats to biodiversity and hot spots, IUCN protected area categories, IUCN Categories of Threats, biodiversity conservation methods- In-situ and Ex-situ conservation
- **Biogeography:** Biogeographical zones of India; forest distribution and types (Champion and Seth); Major biomes- terrestrial (forest ecosystem) and aquatic (fresh water and marine), Wetlands and Mangrove ecosystem

UNIT III Global Issues and Human Ecology 12 Hrs.

- **Global ecological issues-** Greenhouse effect and climate change, ozone depletion, ecosystems responses to long-term climate patterns.

- **Human Ecology-** Urban ecosystem and smart cities; Population growth and environment, response to climate change – mitigation and adaptation, environmental movements.

UNIT IV Sustainability and Sustainable Development 12 Hrs.

Sustainability and Sustainable Development: Sustainability theory, sustainability and society (social justice, development, economy), Desertification and UNCCD, `Agenda-21; UNEP programmes towards sustainable development, Circular economy.

Suggested Readings and References

1. Miller, G. Tyler. and Spoolman, Scott. (2020). Living in the Environment, 20th Edition. Cengage publications.
2. Maiti, P and Maiti, Paulami. (2014). Biodiversity: Perception, peril and preservation. PHI learning pvt. New Delhi
3. Odum, Eugene P., and Gary W. Barrett. (2007). Fundamentals of Ecology, 5th edition. Thomson Brooks / Cole.
4. Primack, Richard B. (2010). Essentials of Conservation Biology, 5th edition. Sinauer.
5. Rogers, Peter P., Kazi F. Jalal, and John A. Boyd. (2007).An Introduction to Sustainable Development. Earthscan.
6. Stiling, Peter. (2001). Ecology: Theories and Applications, 4th edition. Prentice Hall.

Course Expected Outcomes:

CEO_1	Understanding overall ecology, biodiversity and ecosystem linkages.
CEO_2	Understanding various components of ecosystem and its application environment management.
CEO_3	Student will be able to understand the new paradigm of sustainable development and global issues of environment management.

Course Title: ENVIRONMENTAL CHEMISTRY

Course Code: EM-603 **L - 03** **Credits – 03**

Course Objectives:

CO_1	This course is about environmental issues and chemistry behind them. It aims to provide knowledge of environmental chemistry to students so that they can deal with various environmental issues.
CO_2	To give students understanding of the basic concepts that are essential to practice environmental chemistry
CO_3	To make them understand and learn about the nature, reactions and transport of chemical species in different segments of environment and their harmful impacts
CO_4	To provide them skills and knowledge on tertiary water treatment methods and improving environmental quality

UNIT I **9 Hrs.**

Fundamentals: Concept and Scope of Environmental Chemistry, Environmental Components, Fundamentals of chemical bonds, molecules and compounds, Organic functional groups and classes of organic compounds, Thermodynamics: first, second and third law of thermodynamics, Gibb's Energy, Stochiometry, Solubility of gases in water.

UNIT II **9 Hrs.**

Water Chemistry: Acid-base equilibrium, Carbonate system, pH and buffers, Oxidation-reduction, Solution processes and solubility, Redox potential, Complexation and chelation reactions, Concept of salinity, Composition of sea water.
Water quality parameters, Water pollutants: organic, inorganic, radioactive, thermal, Water disinfection methods, Tertiary water treatment methods: Adsorption, Defluoridation, Desalinization through distillation, ion exchange, Reverse Osmosis and Electrodialysis, Water softening.

UNIT III **9 Hrs.**

Soil Chemistry: Composition of soil, Micro and macro nutrients of soil, Nitrogen, phosphorus and potassium in soil, Chemical reactions of soil: ion exchange, ligand exchange, complexation, chelation, precipitation, humus formation, Wastes and pollutants in soil.

UNIT IV **9 Hrs.**

Atmospheric Chemistry: Chemical composition of atmosphere: particles, ions and radicals, Chemical processes for formation of inorganic and organic particulate matter, Chemical and photochemical reactions in the atmosphere, Photochemical smog, Acid rain, Oxygen and ozone chemistry.
Green Chemistry: Concept, Basic principles and tools of Green Chemistry, Zero waste technology.

Suggested Readings and References:

1. Manahan, S. E. (2008). Fundamentals of Environmental Chemistry. 3rd ed. CRC Press, Inc., USA.

2. De, A. K. (2000). Environmental Chemistry. 4th ed. New Age International (P) Ltd., New Delhi, India.
3. Sawyer, C. N., McCarty, P. L. and Parkinn, G. F. (2003). Chemistry for Environmental Engineering and Science, 5th Edition, McGraw-Hill Science.
4. Banerji, S. K. (1999). Environmental Chemistry. 2nded. Prentice-Hall, New Delhi, India
5. Spiro, T., Purvis-Roberts, K. L. and Stigliani, W. M. (2011) Chemisry of the Environment, 3rd Ed., University Science Books, U. S.
6. Gilbert M. Masters and Wendell P. Ela (2009). Introduction to Environmental Engineering and Science, 3rd Ed., PHI Learning Ltd., New Delhi.

Course Expected Outcomes:

CEO_1	This course will help students to understand chemistry of different segments of the environment including soil, water and atmosphere.
CEO_2	The students will be able to learn fundamentals and scope of environmental chemistry.
CEO_3	The students will get proper knowledge about chemical composition of different environment segments and reactions occurring therein.
CEO_4	The students will be able to learn about different principles of green chemistry and its application in improving environmental quality.

Course Title: ENVIRONMENTAL GEOSCIENCES AND NATURAL DISASTERS

Course Code: EM 605 **L-03** **Credits – 03**

Course Objectives:

CO_1	To appraise the students about the concepts of Environmental Geosciences and Applied Geology.
CO_2	To give detail inside knowledge about the physical environments viz., terrestrial, aquatic and atmospheric.
CO_3	To give the concept of natural disasters.
CO_4	To introduce the various disaster mitigation measures for the benefit of environment and society.

UNIT I **9 Hrs.**

Terrestrial Environment: Internal structure of earth-crust, mantle and core; surface features of the earth- landforms created by running water, underground water, wind, glacier, sea; types of rocks and rock cycle; erosion and weathering; soil formation, profile, types and conservation, Earth geodynamics process.

UNIT II **9 Hrs.**

Atmospheric Environment: Atmosphere- pressure, temperature, precipitation, humidity and radiation; Cloud classification and formation; La Nina, El Nino phenomenon; Western disturbances. Aquatic Environment: Hydrological cycle; sea floor spreading, formation of lakes, coastal environment. Applied Geology: Scope of engineering geology; dam impacts, reservoirs, bridges, and tunnels-geotechnical investigation.

UNIT III **9 Hrs.**

Disaster Types (1): Disaster types, Disaster Management Cycle, risk analysis, international and national agencies in disaster management; Hyogo Framework (2005-2015), Sendai Framework (2015-2030), role of media and technology in disaster management. Landslides – types, causes, control and mitigation measures of landslides. Volcanoes - nature, types and extent of volcano, causes of volcanism, volcanic materials, geographic distribution of volcanoes.

UNIT IV **9 Hrs.**

Disaster Types (2)

Earthquakes: Seismology, earthquakes, causes, plate tectonic theory, intensity and magnitude of earthquake, geographic distribution of earthquakes zones, nature of destruction, earthquake mitigation for buildings and dams; seismic zones of India. Coastal hazards: cyclones, tsunami and coastal zone management. Drought: definition, types, assessment and mitigation and drought proofing. Floods: type and causes of floods, drainage basins, nature and frequency of flood, flood hydrographs, flood management and control. Forest fire: causes and consequences, monitoring and mitigation.

Suggested Readings and References:

1. Roy, A.B. (2010). Fundamentals of Geology. Narosa Publishing House.
2. William H. Dennen and Bruce R. Moore (1986). Geology and engineering. WCB Publishers, Iowa.
3. Singh Prabin (2010). Engineering and General Geology. Kataria & Sons Publication.
4. Valdiya, K.S. (1982). Environmental Geology. Tata McGraw Hills Publication.
5. Bimal Kanti Paul (2011)**.** Environmental Hazards and Disasters-Contexts, Perspectives and Management, John Wiley & Sons.
6. Keller, E.A. (1996). Environmental Geology. Prentice Hall, Upper Saddle River, New Jersey.

Course Expected Outcomes:

CEO_1	At the end of the course the student will be able to understand structure and composition of the earth; details about the atmospheric and aquatic environments.
CEO_2	The subject will give in depth knowledge about the characteristics and types of different natural disasters and their global distributions.
CEO_3	The subject will also give inside about the mitigation measures of different natural disasters, which will help in minimizing the impact on environment and society.

Course Title: FUNDAMENTALS OF GEOINFORMATICS

Course Code: EM 607 **L-04** **Credits – 04**

Course Objectives:

CO_1	To give inside details about the subjects Remote Sensing, Geographic Information System (GIS) and Global Positioning System (GPS).
CO_2	To appraise the students how to do different digital image processing techniques and to interpret the remotely sense data in more efficient ways.
CO_3	To make the students understand the types of data used in GIS and how different models are used to represent the real world and their functionalities.
CO_4	To ease the students to understand the applications of Geospatial technology in the fields of environment viz., environment and natural resources management, urban planning, coastal landform studies, snow and glacier studies and in disaster management.

Unit I Remote Sensing Fundamentals **12 Hrs.**

Introduction to geoinformatics, basic principles and definitions of remote sensing, physical basis of remote sensing, electromagnetic spectrum, remote sensing resolutions, radiation laws and atmospheric effects. Basics of optical, thermal and microwave remote sensing. History of remote sensing. Spectral signatures of vegetation, water, soil and snow in different regions of EMS. Remote sensing platforms, orbits and sensor types. Characteristics of IRS, Landsat, SPOT, ERS and other operational remote sensing satellites.

Unit IIRemote Sensing Data Analysis and Global Positioning System (GPS) **12 Hrs.**

Digital Image Processing - image rectification and restoration, image enhancement, data merging, digital image classifications, hyperspectral image analysis, biophysical modelling, image transmission and compression. Visual interpretation – principles, strategies and elements. Basic principles and functions of Global Positioning System and its applicability.

Unit III: Geographic Information System (GIS) **12 Hrs.**

Basic principles and components of Geographic Information System (GIS), spatial information and spatial data types, geographic phenomena, geographic field, geographic objects and boundaries, raster geoprocessing with both regular and irregular tessellations, vector geoprocessing and topology, spatial relations and spatial analysis. Map projection concepts and types. Survey of India topographical map types, numbering system of SOI toposheets, datum and coordinate systems. Remote sensing and GIS software.

Unit IV Geoinformatics in Environment Management **12 Hrs.**

Application of remote sensing and GIS techniques in environment management - natural resources, forests, wetlands, coastal zone, snow and glaciers, land use planning. Remote sensing for disaster management.

Suggested Readings and References:

1. Joseph, George. 2005. Fundamentals of Remote Sensing, 2nd Edition. University Press India.
2. Lillisand, Thomas, Ralph W. Kiefer and Jonathan Chipman. 2007. Remote Sensing and Image Interpretation. Wiley India.
3. Sabins, Floyd F. 2007. Remote Sensing: Principle and Interpretation. Waveland Press.
4. Jensen, John R. 2009. Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition. Dorling Kindersley.
5. Lo, C.P., and Albert K.W. Yeung. 2009. Concepts and Techniques of Geographic Information Systems, 2nd Edition. PHI Learning.
6. Rolf A de By. 2001. Principle of Geographic Information System. ITC Text Book Series. Enschede, The Netherlands.

Course Expected Outcomes:

CEO_1	After completing the course students will enable to understand the basic principles of Remote Sensing, GIS and GPS.
CEO_2	The course will immensely help students to understand the functionality and contributions of different satellite series worldwide.
CEO_3	This will help the students to analyse the spatial data and link them with other attribute data.
CEO_4	Once basic is clear students will have overall idea how this technology can be utilized in different fields of environment with emphasis on natural resource management.

Course Title: ENERGY RESOURCES AND TECHNOLOGY

Course Code: EM 609 **L-04** **Credits – 04**

Course Objectives:

CO_1	To introduce the energy units and basics of renewable and non-renewable energy systems.
CO_2	To introduce various technologies used in non-renewable and nuclear energy and their environmental impacts.
CO_3	To introduce basics and impart the knowledge on various renewable energy technology.
CO_4	To introduce the principles of energy conservation, audit analysis and energy pricing.

UNIT I

Energy and Development: Different forms of energy, Units of Energy; First & second Laws of Thermodynamics, Concept of Entropy, Carnot Cycle; Non-renewable and renewable energy resources, World energy scenario, Energy use in different sectors- Indian scenario, Energy and development issues, environmental implications of fossil fuel burning, nuclear energy issues, Need for new and alternate energy resources. **12 Hrs.**

UNIT II

Conventional Energy Resources, Technology : Coal: reserves, properties, processing, Coal gasification and liquefaction, fluidized bed system and combined power generation cycle; Petroleum: reserves, excavation, recovery, fractional distillation, cracking of petroleum; Natural gas: reserves, extraction and purification, safety issues; Nuclear energy: Nuclear power generation-Fission reactors, Breeder reactors, Fusion technology. Magnetohydrodynamic energy- principle and working of MHD generator, merits, and limitations. Energy Environment issues in carbon capture, utilization and storage. **12 Hrs.**

UNIT III

Renewable Energy resources : Solar energy-Flat plate collectors, photovoltaic cells , Solar power; Wind energy, wind farms ; Geo-thermal energy ; Hydropower-mini and micro-hydro power; Tidal energy, Ocean Thermal Energy Conversion Technology(OTEC); Biomass energy-biomass gasification for thermal, electrical and mechanical power generation, biomass gasifier systems, gasifier coupled dual fuel engine system, improved biomass cooking stoves; Anaerobic digester for biogas: basic processes and energetics; Energy plantations, Bioconversion technologies; Hydrogen as alternate fuel -Production methods, Biohydrogen. **12 Hrs.**

UNIT IV

Energy Conservation and Energy Economics: Principles of energy conservation, Energy efficiency at national level, improving energy efficiency, Concept of Green buildings; energy analysis, concept of exergy, (theoretical treatment), capital recovery factor, levelized annual cost, economic analysis of wind electric generation and thermal power systems; Concept of energy audit, Case study of an industry. **12 Hrs.**

Suggested Readings and References:

1. Edward H. Thorndike (1976), Energy & Environment: A Primer for Scientists and Engineers, Addition-Wesley Publishing Company, Reading.
2. Rakos Das Begamudre (2000), Energy Conversion Systems, New Age Int Publishers, New Delhi.
3. C. S. Solanki (2009), Renewable Energy Technologies-A Practical Guide for Beginners, PHI Learning Pvt. Ltd., New Delhi
4. Y P Abhi and S.Jain (2006). Handbook on Energy audit and Environment Management, TERI
5. D. D. Mishra (2012) Energy, Environment, Ecology and Society, S. Chand & Company Ltd. New Delhi.
6. R. D. Begamudre (2000). Energy conversion systems, New Age International Publishers, New Delhi

Course Expected Outcomes:

CEO_1	Students will learn basics of energy units and relation of energy with development.
CEO_2	Students will be able to learn the utilization of various technologies used in non-renewable energy systems.
CEO_3	Students will develop know-how different renewable energy technologies.
CEO_4	Students will develop concepts and competence on energy conservation and energy economics.

Course Title: ENVIRONMENTAL STATISTICS

Course Code: EM 611 **L-03** **Credits – 03**

Course Objectives:

CO_1	An advanced understanding of the statistical theory and probabilities.
CO_2	Shall aid in analysing various statistical methods for important problems in environmental sciences.
CO_3	Shall elaborate the application of statistical techniques on environmental data.
CO_4	Shall help in interpreting the results so obtained.

UNIT I **9 Hrs.**

An overview of environmental systems, Basic definitions and applications, Generation of environmental data; Types and objectives of environmental studies; Discrete and continuous variables; levels of measurement of environmental data; Accuracy and precision; Parameter and statistic; Significance / relevance of data analysis in environmental management.

UNIT II **9 Hrs.**

Sampling representative sample size, sampling bias and sampling techniques. Data collection and presentation: Types of data, methods of collection of primary and secondary data; Methods of data collection; Methods for selecting sampling locations and times; Simple random sampling, Stratified random sampling, Systematic sampling; Graphical representation by histogram, polygon and pie diagram.

UNIT III **9 Hrs.**

Measures of central tendency; Mean, median, mode; Sampling distributions of - Means, Difference of means, Proportion, Variances, Covariance; Estimation of parameters: Point and Interval estimates; Confidence interval estimation of - Means, Difference of means; Correlation and regression: positive and negative correlation and calculation of Karl pearsons co-efficient of correlation; Linear regression and regression equation, Calculation of an unknown variable using regression equation; ANOVA, one way classification

UNIT IV **9 Hrs.**

Tests of Hypotheses: Null and Alternative Hypothesis; Type I and Type II Errors; Level of significance; Parametric tests (Concerning Means, Difference of means, Proportion, Variances): Tests of significance for large samples: Z test , Types of Z test (one sample and two sample) , Standard error for Z test ; Tests of significance for small samples: T-test (One sample, Two Sample: Independent and Dependent), Standard error for T-test; F-test for comparison of variance ; Goodness-of-fit test – Chi-Square test; Test for quality of data: Qtest; Nonparametric tests – Sign test, Wilcoxon Signed Rank test , Kruskal-Wallis test.

Suggested Readings and References:

1. Joseph, A.J. (1997). Health, Safety and Environmental Data Analysis, Lewis Publishers, New York.
2. Pentecost, A. (2003). Analysing Environmental Data. Longman, London.
3. Gilbert, R.O. (1987). Statistical Methods for Environmental Pollution Monitoring, New York, Van Nostrand Reinhold.
4. McBeen, E.A. (1999). Statistical Procedures for Analysis of Environmental Monitoring Data.
5. Keith, L.H. (Ed.) (1988). Principles of Environmental Sampling ACS Professional References, American Chemical Society.
6. Berthouex, P.M. and Brown, L.C. (1994). Statistical for Environmental Engineers. Lewis Publishers, CRC Press.

Course Expected Outcomes:

CEO_1	Collating and treating data through various statistical methods.
CEO_2	Understanding the application of statistical techniques to specific problems.
CEO_3	Learning which test shall be applied where.
CEO_4	Interpreting the results obtained after application of statistical parameters.

Course Title: SEMINAR/TERM PAPER *

Course Code: EM 613 **L-01** **Credits – 01**

Course Objectives:

CO_1	The students will get an opportunity to identify a topic for an in-depth analysis.
CO_2	Term paper will provide an understanding on how to write a research article.
CO_3	Presentation, research and academic writing skills will be improved.
CO_4	Provide an opportunity for some individual interaction between the student and faculty.

Methodology of term paper

- Students are required to select a topic of their own choice from the current contemporary topics or select a topic after consultation course coordinator and other faculty.
- The word limit of the term paper is 5000 words (excluding references). Please do not exceed the word limit.
- The term paper shall have a proper structure- Abstract, Table of contents, Introduction, Objectives, Problem statement, Literature Review, Methodology, Results and Discussion, Conclusion and Reference.
- Plagiarism shall be checked, refrain from copying. The sources of articles to be reviewed should be peer-reviewed journal articles and books; and properly referenced throughout the contents of term paper. References should be in APA/Harvard format.
- The assessment shall be based on criteria – viz. contents and clarity in term paper, presentation, adherence to the deadline, plagiarism report.
- The term paper shall be submitted through a softcopy and a hard copy to the Course Coordinator.

Course Expected Outcomes:

CEO_1	Students will write a paper that locates and synthesizes relevant primary and secondary sources of data and has a clear, coherent and plausible argument, logical structure, correct grammar and proper references (footnotes and bibliography).
CEO_2	Students will learn new research methods and review existing literature, which will enable them to understand their topics in-depth and critically think regarding solutions.

CEO_3	Use writing to learn and synthesize new concepts- the students receive feedback that helps them develop their research, writing and presentation skills, evidence and support an argument.
CEO_4	Formulate and express opinions and ideas in writing- the contents should be critical and analytical, hence encouraging students to develop critical thinking skills.

Course Title: GEOINFORMATICS LAB

Course Code: EM 651 **P-04** **Credits – 02**

Course Objectives:

CO_1	The main objectives of this subject are to give the hands-on experiences in the fields of Remote Sensing, GIS and GPS both at laboratory and field level.
CO_2	To discuss details about different image processing techniques including how a raw image can be registered and be utilized for development purposes.
CO_3	To give practical knowledge how to create geodata base and how different methods can be utilized to solve certain problems using case studies.
CO_4	To give practical exposure how to collect field data using GPS and to import those on map to prepare a final output map.

LIST OF EXPERIMENTS

1. Introduction to the software - ArcGIS and Erdas Imagine
2. Digital Image Classification – Supervised and Unsupervised
3. Georeferencing - Scanned topographical map and image to image georeferencing
4. Mosaicking
5. Fusion - Merging of high and low spatial and spectral resolution imagery
6. Subset of imagery
7. Creation of geodatabase
8. Query and retrieval, overlay and map composition
9. Field data collections using GPS and importing to the maps

Suggested Readings and References:

1. Joseph, George. 2005. Fundamentals of Remote Sensing, 2nd Edition. University Press India.
2. Lillisand, Thomas, Ralph W. Kiefer and Jonathan Chipman. 2007. Remote Sensing and Image Interpretation. Wiley India.
3. Sabins, Floyd F. 2007. Remote Sensing: Principle and Interpretation. Waveland Press.
4. Burrough, P.A. 1976. Principles of Geographic Information System for Land Assessment. Oxford: Clarandon Press.
5. Lo, C.P., and Albert K.W. Yeung. 2009. Concepts and Techniques of Geographic Information Systems, 2nd Edition. PHI Learning.
6. Rolf A de By. 2001. Principle of Geographic Information System. ITC Text Book Series. Enschede, The Netherlands.

Course Expected Outcomes:

CEO_1	After completing the course students will enable to handle both the image processing and GIS software.
CEO_2	Students will be able to generate geodata base and how different queries could be applied on these databases to solve certain problem.
CEO_3	Students also be able to interpret the raw image using different digital image processing techniques.
CEO_4	Students will be confident how field data can be collected with the help of GPS and to bring them on the map.

Course Title: ENVIRONMENTAL CHEMISTRY AND ENERGY LAB

Course Code: EM 653 **P-04** **Credits – 02**

Course Objectives:

CO_1	The practical course is designed to impart basic knowledge of water and fuel quality parameters.
CO_2	To train the students to get qualitative and quantitative information on chemical characteristics of water and wastewater samples.
CO_3	To enable students to learn proximate analysis of biomass
CO_4	To impart training to students to study P-V characteristics of photovoltaic system.

LIST OF EXPERIMENTS

1. Determination of pH value of a given water sample.
2. Determination of Acidity of given water sample.
3. Determination of Alkalinity of given water sample.
4. Determination of Hardness of given water sample.
5. Determination of Chloride content in given water sample.
6. Determination of Dissolved Oxygen of given water sample.
7. Determination of Turbidity of given water sample.
8. Determination of Volatile matter in a given solid sample of Biomass
9. Determination of the Ash content and Mineral matter in a given sample of Biomass
10. Determination of Volatile matter and Fixed carbon in the given agro-waste residues
11. Estimation of Volatile matter Ash content and Mineral matter in a given solid sample of Bituminous Coal
12. Estimation of Calorific value of a sample of solid fuel using Bomb calorimeter.
13. To Study of I-V and P-V Characteristics of PV module with changing radiation and temperature and to calculate the fill factor from I-V curve.
14. Study of P-V characteristics of photovoltaic system with different tilt angles and varying radiation

Suggested Readings and References:

1. Garg S.K., (2019). Water Supply Engineering, 33rd ed., Vol.1, Khanna Publishers.
2. S. K. Bhasin and S. Rani (2006). Laboratory Manual on Engineering Chemistry. Dhanpat Rai Publishing Company.
3. APHA (2005), Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association.
4. D.P. Kothari, D.K. Sharma. Energy Engineering: Theory and Prac (2000). S. Chand & Company Ltd., New Delhi.
5. P.V.R. IYER, T.R. Rao, P.D. Grover, and N.P. Singh (1997). Biomass: Thermo-chemical Characterization. 2nd Edn, IIT Delhi.
6. Guide Manual for Water and Wastewater Analysis, CPCB.

Course Expected Outcomes:

CEO_1	The students will be able to understand the significance of determining water quality.
CEO_2	The students will be able to measure water quality parameters and check their compliance with standards. They will also get knowledge on tertiary water treatment methods.
CEO_3	The students will learn to determine volatile matter, ash content and mineral matter of fuels.
CEO_4	The students will learn how PV module characteristics change with radiation and temperature conditions.

Course Title: ENVIRONMENTAL STATISTICS AND COMPUTER APPLICATION LAB

Course Code: EM 655 **P-04** **Credits – 02**

Course Objectives:

CO_1	Prepare students to apply basic statistical concepts in environmental problems.
CO_2	Enhance the basic understanding of application of various tests depending on the problem.
CO_3	Data visualization and reasoning of statistical results.
CO_4	Interpretation of results through computer programming.

LIST OF EXPERIMENTS

1. To determine the descriptive statistics for the data set.
2. To construct Box plot, Individual value plot and histograms for the given data set and interpret the same.
3. To develop null and alternate hypothesis.
4. To understand the concept of standard error and confidence interval.
5. To understand sampling distributions and find central tendency.
6. To conduct one sample and two sample Z-test.
7. To conduct a t-test and interpret using standard values.
8. To conduct one sample T-test
9. To conduct two sample T test
10. To conduct a paired T-test to evaluate two test procedures and dependent data sets
11. To check for bias and significance of results for T-test
12. To carry out non parametric Mann Whitney Test for a sample.
13. To evaluate correlation between two parameters at various significance level.
14. To find a regressive coefficient and fit a linear model for a problem

Suggested Readings and References:

1. Wayne R Ott (1994). Environmental Statistics and Data Analysis , Lewis Publishers, New York.
2. Framework for the development of Environmental Statistics (2013) , United nations
3. Gilbert, R.O. (1987). Statistical Methods for Environmental Pollution Monitoring, New York, Van Nostrand Reinhold.
4. McBeen, E.A. (1999). Statistical Procedures for Analysis of Environmental Monitoring Data.
5. Keith, L.H. (Ed.) (1988). Principles of Environmental Sampling ACS Professional References, American Chemical Society.
6. Berthouex, P.M. and Brown, L.C. (1994). Statistical for Environmental Engineers. Lewis Publishers, CRC Press.

Course Expected Outcomes:

CEO1	Understanding the basics of sampling and data generation techniques.
CEO2	Learning various parametric and non-parametric tests.
CEO3	Application of various statistical tests on environmental data.
CEO4	Interpretation of the results.

SECOND SEMESTER

Course Title: AIR POLLUTION, METEOROLOGY AND CONTROL

Course Code: EM-602 **L : 04** **Credits: 04**

Course Objectives:

CO_1	To introduce the concept air quality and air emission standards.
CO_2	To acquaint with the fundamentals of meteorology and atmospheric stability.
CO_3	To familiarize student about atmospheric diffusion and indoor air quality models.
CO_4	To introduce pollution control technologies of gaseous and particulate emissions for stationery and mobile sources.

UNIT I **12 Hrs.**

Introduction to Air Pollution: Air quality and emission standards, air pollution standard, Air Quality index, criteria pollutants, sources and classification of air pollutants, effects of air pollution on human health, vegetation and property, primary and formation of secondary air pollutants, role of VOCs in ground ozone formation, global implication of air pollution (Greenhouse gases, ozone layer depletion, photochemical smog, ozone and acid rain).

UNIT II **12 Hrs.**

Air Pollution Meteorology Fundamentals: Meteorological scales of motion, environmental and adiabatic lapse rates, atmospheric boundary layer, pressure and temperature relationship in the lower atmosphere, vertical temperature variation, moisture, atmospheric stability and mixing height, temperature inversions, saturated lapse rate and cloud formation, adiabatic diagram, and wind roses.

UNIT III **12 Hrs.**

Atmospheric Diffusion Theory: Elementary overview of various atmospheric diffusion theories, steady-state atmospheric diffusion equation, diffusion models, wind speed change with elevation, Gaussian concentration distribution- Gaussian plume idea, Gaussian plume derivation as solution of the atmospheric diffusion equation, dispersion parameters in Gaussian models, Pasquill-Gifford Curves; Plume Rise –Momentum and Buoyant Plumes.

Sampling and Monitoring of Air Pollutants : Scope, purpose and objectives of air quality monitoring; preliminary survey required for planning an air quality survey; guidelines for planning a survey; design of an air quality surveillance network; sample size; theory and principles of instruments for measurements of – ambient air pollution; and stack monitoring.

Indoor air pollution: indoor air pollutants; indoor air quality model; infiltration and ventilation, control of indoor air quality.

UNIT IV **12 Hrs.**

Air Pollution Control Technologies: Stationery sources, air pollution control philosophies-emission standards, emission tax and Cost-benefit, general ideas in air pollution control, alternative control measures, low NO_X combustion, control of particulate contaminants, nature of particulate contaminants, PM_{10}, $PM_{2.5}$& PM_1 particle size distribution, distribution by mass and number, behavior of particles in the atmosphere, particulate control methods and devices: Wall collections devices-selection of particulate collection device, control of gaseous contaminants: gaseous control methods and devices – absorption, adsorption, flue gas desulfurization, combustion and condensation, control of mobile sources emissions.

Suggested Readings and References:

1. Fredrick K. Lutgens; Edward J. Tarbuck and Dennis Tasa. (2015). The Atmosphere An Introduction to Meterorology, Pearson Education Inc.
2. Seinfeld, J. H. (1986). Atmospheric Chemistry and Physics of Air Pollution, Wiley Interscience, New York.
3. Peavy, H. S., Donald, R. R., Tchobanoglous, George. (2013). McGraw Hill Education (India) Private Limited, Chennai
4. Bruno Sportisse (2010), Fundamentals in Air Pollution – From Processes to Modeling, Springer.
5. Perkins, H. C. (1974). Air Pollution, McGraw-Hill, New York.
6. Thomas G. Spiro., Kathleen Purvis-Roberts and William M. Stigliani (2017). Chemistry of the Environment, Viva Books, New Delhi.

Course Expected Outcome:

At the end of the Course, the Student will be able to-

CEO_1	Understand the basics of air pollution and their effects on human health.
CEO_2	Develop and understand theories of air pollution meteorology and atmospheric stability.
CEO_3	Develop concepts of air pollution models and understand sampling of indoor and outdoor air pollutants.
CEO_4	Understand and learn application of various air pollution control technologies in gaseous and particulate emissions.

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Course Title: WATER POLLUTION AND WASTEWATER TREATMENT

Course Code: EM-604 **L : 04** **Credits: 04**

Course Objectives:

CO_1	The purpose of this course is to make students aware and knowledgeable about different types of water pollutants and their impacts.
CO_2	The primary objective of this course is to enable students to learn principles of different conventional and advanced water and wastewater treatment technologies.
CO_3	To understand and learn various cost effective and environment friendly techniques for domestic wastewater treatment as well as their implementation in different sectors for wastewater treatment.
CO_4	To recognize and explore approaches towards safe and healthy environment.

UNIT I Water Sources: **12 Hrs.**

Availability and quality of surface water and ground water, Impact of ground water development and depletion, Status and trends of surface water utilization and consumption.

Water Pollution: Sources and types of water pollution, Water quality standards, Eutrophication, Effects of various water pollutants, Groundwater pollution, Pollution of major rivers in India, National River Action Plan, Marine pollution, Thermal pollution of water bodies.

UNIT II Water Treatment Technologies: **12 Hrs.**

Water treatment flow sheet; Principles, application and design types: Aeration, coagulation, flocculation, sedimentation; filtration; Drinking water quality standards.

UNIT III Wastewater Treatment: **12 Hrs.**

Characterization, Disposal standards, BOD growth curve, estimation of BOD rate constant by Thomas Slope method, Self purification of waste in streams.Conventional sewage treatment plant flow sheet, Physical treatment processes- screen chamber, grit chamber, primary and secondary settling tanks, sludge drying beds, belt filter press, vacuum filtration.

UNIT IV Biological treatment Technologies: **12 Hrs.**

Aerobic and anaerobic processes, Operational principles and working of activated sludge process andTrickling filter, Rotating Biological Contactors, Extended aeration. Upflow anaerobic sludge blanket (UASB) reactors, Anaerobic fixed film bed reactor, anaerobic fluidized bed reactor; Sludge stabilization using anaerobic digestors.
Low cost technologies: Septic tank, Imhoff Tank, Aerobic lagoons, Oxidation pond, High Rate Algal Ponds.

Suggested Readings and References:

1. Garg S.K., (2019). Water Supply Engineering, 33rd ed., Vol.1, Khanna Publishers.

2. Mark J. Harmmer, Mark J. Harmmer, Jr. (2009). Water and Wastewater Technology, 6th Ed. PHI Learning Pvt. Ltd., New Delhi.
3. Gilbert M. Masters and Wendell P. Ela (2009). Introduction to Environmental Engineering and Science, 3rd Ed., PHI Learning Ltd., New Delhi.
4. Marcos von Sperling (2007). Wastewater characteristics, treatment and disposal, IWA Publishing, London.
5. Metcalf and Eddy (2003). Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi.
6. Qasim Syed R. (1999). Wastewater Treatment Plants: Planning, Design and Operation, 2nd ed., Technomic Publishing Co., Inc.

Course Expected Outcomes:

CEO1	The students will be able to understand the current status of surface and ground water quality in India along with the impacts of various water pollutants.
CEO2	Students will be able to understand the importance of treatment of water collected from natural resources and in-depth knowledge of various water treatment processes.
CEO3	Course will impart knowledge about the characteristics of sewage wastewater and importance of its treatment before disposal.
CEO4	Students will gain knowledge and acquire in-depth understanding on sewage treatment and sludge management methods so as to protect human health and environment.

Course Title: BASIC AND APPLIED ENVIRONMENTAL MICROBIOLOGY

Course Code: EM 606 **L-04** **Credits – 04**

Course Objectives:

CO_1	To provide knowledge of environmental microbiology to students.
CO_2	To provide basic understanding of diversity and functions of microorganisms in different components of environment including soil water and air.
CO_3	To provide knowledge on potential of microbes in pollution remediation.
CO_4	To provide knowledge on role of microbes in environmental protection and sustainability.

UNIT I **12 Hrs.**

Introduction to Microbes: Diversity of microorganisms, Characteristics and environmental significance; Microbial growth and metabolism.

Microbiology of soil: Microbial habitats; Microbial interactions in soil; Microorganisms and biogeochemical cycles: Nitrogen transformations - Ammonification, Nitrification, Denitrification, Symbiotic and non-symbiotic nitrogen fixation; Carbon Transformations- Mineralization, microbial degradation of cellulose, hemicelluloses, lignin, chitin, pectin; Microbial transformation of sulfur, phosphorus, iron and manganese.

UNIT II **12 Hrs.**

Aquatic and Aeromicrobiology: Microbial habitats and diversity in the aquatic environment, Planktons, Benthic microbes, Microbial mats, Biofilms, Indicator microorganisms, Microbes and climate change mitigation. Aeromicrobiology, Aeromicrobiological pathway, Important airborne pathogens; Bioaerosols, Control of bioaerosols; bio-scrubbers and bio-filters;

UNIT III **12 Hrs.**

Application of microbes in remediation: Microbial degradation and bio-transformation of xenobiotics; Metal bioavailability; Microbial removal of toxic metals; Biomethylation of metals. Microbially induced corrosion; Acid mine drainage, microbial bioleaching of ores; Microbial desulfurization of coal; Microbially enhanced oil recovery.

UNIT IV

Application of microbes in Agriculture and Resource recovery **12 Hrs.**

Mycorrhizal diversity and interactions; Environmental applications of mycorrhizal associations; Soil biological control of plant diseases; bio-fertilizers; bio-pesticides; Vermicomposting, Role of microbes in alternate energy generation; microbial fermentation; Role of microbes in effluent treatment; microbial recovery of vital elements.

Suggested Readings and References:

1. Raina M. Maier (2008). Environmental Microbiology. Academic Press.
2. Pelczar, M.J., E.C.S. Chan & N.R. Krieg, (1998). Microbiology. Tata McGraw Hills
3. Gabriel Bitton (1999). Wastewater Microbiology, 2nd Ed., Wiley-Liss, New York.
4. Black, Jacquelyn G. (2008). Microbiology: Principles and Explorations.Wiley.
5. Alan Scragg (2005). Environmental Biotechnology, 2nd Ed., Oxford University Press.

6. Mark Coyne (2001). Soil Microbiology: An Exploratory Approach. Thomson Business Information.

Course Expected Outcomes:

CEO_1	The students will be able to understand the habitats and diversity of microorganisms in different types of environment.
CEO_2	The students will learn about the role of microbes in various biogeochemical cycles.
CEO_3	The students will get knowledge about potential applications of microbes in pollution abatement and resource recovery.
CEO_4	The students will learn about the role of microbes in sustainable agriculture and energy production.

Course Title: SOLID AND HAZARDOUS WASTE MANAGEMENT

Course Code: EM-608 **L - 03** **Credits – 03**

Course Objectives:

CO_1	The course is designed to impart an in-depth knowledge on solid and hazardous wastes including their classification, properties, harmful impacts and management.
CO_2	It aims to provide students understanding and learning of all functional aspects of solid waste management including generation, storage, collection, transportation, processing and disposal.
CO_3	To provide knowledge on various technologies for sustainable treatment of solid waste and resource recovery from the waste.
CO_4	To provide them skills and knowledge on disposal of solid and hazardous waste in environmentally-safe manner.

UNIT I **9 Hrs.**

Introduction: Definition, Sources and type based classification, Municipal soild wastes, Industrial wastes and hazardous wastes, Environmental and health impacts due to solid wastes, Integrated solid waste management, Present scenario of MSW in India, **Properties of solid waste:** Physical and chemical composition of MSW, Waste generation rates, factors affecting solid waste generation, waste reduction at source.

UNIT II **9 Hrs.**

Municipal solid waste management in India: Waste storage at source, Collection of wastes, Transfer and transportation of wastes, Design specifications of waste storage bins, Waste collection tools and methods, Waste transportation vehicles and methods, Role of transfer stations, Importance of proper waste treatment and disposal.

UNIT III **9 Hrs.**

Treatment (Processing) and Disposal techniques: **Composting-**Definition and principle, Aerobic composting, Anaerobic composting, Mechanical composting, Vermicomposting, Advantages and limitations of composting techniques. **Anaerobic digestion (Biogasification):** Definition and mechanism, Objectives and Development of biogas plants in India, Traditional digesters such as KVIC plant, Deenbandhu model, Emerging technologies. **Thermal Processing:** Incineration, Pyrolysis, gasification, RDF system, Merits and demerits of various methods. **Landfilling:** Planning and site selection, EIA of proposed site, Methods of site preparation, Land filling techniques, Landfill operations and maintenance, Leachate collection and treatment, Landfill gas emissions and methane recovery, Post-care closure and use of old landfills.

UNIT IV **9 Hrs.**

Hazardous waste management: Definition and characteristics, Sources and type based categorization, Treatment technologies: Physico-chemical, thermal, biological, sea and land disposal, Hazardous Waste (Management & Handling) Rules, Basel convention. **Biomedical wastes:** Definition, Sources, Generation, Segregation and storage of biomedical waste, Packaging, Handling and Transport of wastes, Treatment and disposal techniques, Biomedical Waste (Management & Handling) Rules. **E-Waste:** Definition and sources, Environmental and health impacts, Treatment and management, E waste (Management & Handling) Rules. **Radioactive**

wastes: Types and sources, waste disposal techniques and management.

Suggested Readings and References:

1. CPHEEO (2000 and 2016). Manual on Municipal Solid Waste Management, Government of India, New Delhi,
2. Tchobanoglous G., Theissen H., and Eliassen R. (1991), *Solid Waste Engineering - Principles and Management Issues*, McGraw Hill, New York.
3. Peavy, A. S., Row, D. R., Tchobanoglous G. (1985). Environmental Engineering, McGraw Hill, Singapore.
4. Freeman H.M. (1988) Standard Handbook of Hazardous Waste Treatment and Disposal, McGraw Hill. New York.
5. Ramachandra, T. V. (2011) Management of Municipal Solid Waste. TERI Press, New Delhi.
6. Papers published in various Journals & Magazines.

Course Expected Outcomes:

CEO_1	After studying this course, the students will be able to understand different types of solid wastes, their sources and characterization.
CEO_2	The students will be able to understand the problems associated with solid and hazardous wastes and importance of its proper management.
CEO_3	The students will get detailed knowledge on resource recovery options from solid wastes.
CEO_4	The students will acquire in-depth understanding on different processes for treatment and safe disposal of different types of solid wastes so as to protect human health and environment.

Course Title: ENVIRONMENTAL POLICIES, ETHICS AND LEGISLATION

Course Code: EM 610 **L - 03** **Credits – 03**

Course Objectives:

CO_1	To introduce the concept of National and International environmental laws and policies for environment management.
CO_2	To introduce the importance of regulatory agencies and their role in environment management.
CO_3	To impart the knowledge about the existing environmental legislations and policies of our country to control pollution.
CO_4	To introduce and understand about the environment management principles, systems and landmark judgments of India for the conservation of environment.

UNIT I **9 Hrs.**

International Environmental Laws: Evolution and development of International Environmental laws with reference to Stockholm Conference, Nairobi Declaration, Basel Convention (1989 and 1992), Rio+10 (Johannesburg Summit), Rio+20 etc. Agenda-21, Convention on Biodiversity. Global environmental issues and laws: to control Global warming, Ozone depletion, hazardous waste, CITES etc. Role of UN in protection of Global Environment, Multinational authorities and agreements**,** Sustainable development goals (SDGs).

Environmental Policies and Strategies in India: Overviews of Environmental laws in India, Evaluation of environmental policies and laws in India, regulatory agencies and their role in environment management, role of NGO, role of courts in environment protection, National Action Plan on Climate Change (Eights National Missions).

UNIT II **9 Hrs.**

Environmental legislation and policies: Duties and responsibilities of citizens in environmental protection, important legislations related to environment: Wildlife Protection Act 1972, The Water (Prevention and Control of Pollution) Act 1974, Prevention and Control of Air Pollution Act 1981, Forest Conservation Act 1981, Noise Pollution (Regulation and Control) Rules, 2000; Environment (protection) Act 1986, Motor Vehicle Act, 1988, Hazardous and other waste (Management and Transboundary Movement) Rules, 2016; Disaster management Act 2005, The Plastic Waste Management Rules, 2016; The Solid Waste Management Rules, 2016; The e-waste (Management) Rules, 2016; The Batteries (Management and Handling) Rules, 2010; The Public Liability Insurance Act, 1991; The Bio-Medical Waste Management Rules, 2016;, Green Tribunal Act, 2010, Coastal Zone Management Act 2009, Disaster management policy 2009, Amendments of Indian Acts & Rules, International environmental law and global issues. National Land use Policy 2019, The Solid Waste Management Rules Specific to COVID-19 Pandemic, 2020.

UNIT III **9 Hrs.**

Pollution Prevention and Total Quality Environmental Management: Environment

management Principles; Environmental indicators; ISO/TC-207 standards; Environment

Management System Standards (ISO 14000 series) and eco labeling schemes. Environmental audit; Guidelines for environmental audit; Sustainable Development Tools and Life Cycle Assessment, Evolution of life cycle analysis (LCA); technical frame work for LCA; life cycle inventory and methodology with case study.

UNIT IV **9 Hrs.**

Environmental Ethics and Landmark Judgments: Value education and community, Corporate social responsibility. Movements related to Environment – Sacred groves, Bishnoi tradition, Environmental movements.

.

Suggested Readings and References:

1. Kulkarni, V. & Ramachandra, T.V (2011). Environment Management, TERI, New Delhi
2. Krishnamurthy, B. (2017). Environmental Management, Text and Case studies 3rd edition. PH Learning Pvt. Ltd., New DelhiI
3. Marry Ann Curran (1996). Environmental Life-Cycle Assessment, McGraw Hill, New
4. Keshav, K. (2017). Law and environment. Singhal Law Publication, Delhi
5. P. Sands (2003). Principles of International Environmental Laws, Cambridge University Press.
6. Sankar, R.N. (2015). Environment Management. Oxford University Press, New Delhi

Course Expected Outcomes:

CEO_1	Students will be able to learn about the importance of National and International environmental laws and policies for environment management.
CEO_2	Students will be able to acquire the knowledge about the role of regulatory agencies in environment management and National Action Plan on Climate Change.
CEO_3	Students will be able to learn about the different existing environmental legislations and policies of our country to control pollution.
CEO_4	Students will be able to acquire the knowledge how environment management principles, systems and landmark judgments works for the conservation of environment in our country.

Course Title: HUMAN VALUES AND ETHICS

Course Code: HVE 102 **L - 02** **Credits – 02**

Course Objectives:

CO_1	To develop a universal approach towards human values.
CO_2	To be able to strike a balance between aspirations and happiness.
CO_3	To understand that humans are a part of nature and how being close to nature bring in joy and satisfaction.
CO_4	Select classical short stories from Indian context will expose the students to diverse and multifaceted subsections in Indian society.

Unit I

The Problem and Paradox of Happiness: Twin goals: happiness and just order; role of value education. Concept of good life-quality of life and subjective well-being; happiness, life satisfaction and positive affect; studying quality of life through surveys; and findings of quality of life surveys. Moral and Institutional approaches; and the inherent conflict between the two. Man and Society.

6 Hrs.

Unit II

Happiness and Nature: Biophilia hypothesis- connections with nature and co-existence with other forms of life, Deep Ecology, Importance of meaningful contact with the natural world, solutions for a healthier, greener tomorrow, Indigenous and traditional knowledge system and its intellectual roots.

6 Hrs.

Unit III

Basics of Professional Ethics, Ethical Human Conduct: Human Conduct- based on acceptance of basics Human Values, Humanistic Constitution and Universal Human Order-skills, sincerity and fidelity. To identify the scope and characteristics of people-friendly and eco-friendly production systems. **6 Hrs**.

Unit IV

Encompassing Different Stories/ narratives on Human Values from Indian Context. 6 Hrs.

Suggested Readings and References:

1. Gaur, R.R., Sangal, S.and Bagaria, G., "A Foundation Course in Human Values and Professional Ethics", New Delhi: Excel Books, 2010.
2. Mike, W. Martin, "Paradoxes of Happiness", Journal of Happiness Studies, 2008, pp. 171-184.
3. Giddens, Anthony, "Sociology", 5th edition, Cambridge: Polity Press, 2006.
4. Ambedkar, B.R., Buddha and his dhamma, http://www.scribd.com/doc/16634512/Buddha-and-His-Dhamma-by-B-R-Ambedkar-Full [accessed on 21 October, 2010]
5. Beteille Andre, "Antinomies of Society: Essays on Ideologies & Institutions", New Delhi: Oxford University Press, 2000.
6. Fikret Berkes, "Sacred Ecology", Second Edition Routledge Taylor & Francis Group, 2008.

7. Richard Louv, "Last Child in the Woods", Algonquin Books, 2008.
8. Ramakrishnan, E.V., "Indian Short Stories": (18700-200). Sahitya Akademi, 2012.
9. Davidar, David., "Cluch of Indian Masterpieces", Aleph Book Company, 2016.
10. "Contemporary Indian Short Stories", Sahitya Akademi, 2014.

Course Outcomes:

CO_1	The students will get sensitized about the role of value education and learn to balance ambition & happiness.
CO_2	The students will be able to understand the importance of living in harmony with nature.
CO_3	The students will be able to see the relevance of Professional behavior and ethics.
CO_4	They will draw inspiration from the classical Indian literature narrated to them in the form of select short stories.

Course Title: ENVIRONMENTAL MODELLING

Course Code: EMGE 616 **L-04** **Credits – 04**

Course Objectives:

CO_1	Understanding of the basics of application of various models in environmental systems.
CO_2	Shall delve in elaborating the tools in mathematical modelling of environmental systems
CO_3	Elaborate the methodology required for modeling of both water and air quality
CO_4	Deliberate on various approaches and explain the limitations in application of various models in environment

UNIT I **12 Hrs.**

Introduction: Environmental systems - an introduction; An overview of mathematical models applied to various environmental issues; Concept, need, scope and objectives of environmental modelling; Model classification – Brief review of different types of models: Mathematical (Deterministic), Numerical, Stochastic & Physical Models

UNIT II **12 Hrs.**

Air Quality Modelling: Air Quality Modelling – Historical perspective; Air quality models – objectives and aim of Modelling; Approaches to model building, elements of air quality models, classification of models; Gaussian Plume model – Point source models

UNIT III **12 Hrs.**

Water Quality Modelling

General: Water Quality Modelling – Historical Perspective; Water Quality Models and Water Resource Management systems.

Fundamentals of Water Quality Modelling: Mass Balance, Steady-State Solution, and Response Time; Control-Volume Approach; Particular solutions; Completely mixed system - concept of continuously stirred tank reactors (CSTR); Different types of loading, Feedforward and feedback systems of reactors. Incompletely mixed system**:** Diffusion.; Distributed Systems (Steady-State). Distributed Systems (Time-Variable).

UNIT IV **12 Hrs.**

Surface Water Quality Modelling: River and streams; Estuaries and Lakes; Dissolved Oxygen Models: DO sag model; BOD and Oxygen Saturation; Gas Transfer and Oxygen Reaeration; Streeter Phelps equation for point sources; Elements of Ground Water Modelling**:** Brief overview.

Suggested Readings and References:

1. Thomann, R.V. and Mueller, J.A. (1987). Principles of Surface Water Quality Modelling and Control, Harper & Row, New York.
2. Chapra, S.C. (1997). Surface Water-Quality Modelling. McGraw-Hill International Edition.

3. Benarie, M.M. (1980). Urban Air Pollution Modelling (Cambridge, MA: The MIT Press).

4. Hipel, K.W. and Mcleod, A.I. (1994). Time series Modelling of Water Resources and Environmental Systems. Elsevier Science B.V. Amsterdam, Netherlands.
5. Buonicore, A.J. and Davis, W.T. (1994). Air Pollution Engineering Manual.Air and Waste Management Association, New York, Van Nostrand Reinhold.
6. Nirmalkhandan N. (2001) Modeling Tools for Environmental Engineers and Scientists, CRC Press, Boca Raton, Florida.

Course Expected Outcomes:

CEO_1	Imparting a basic understanding of various environmental systems.
CEO_2	How the systems can be categorized for modelling.
CEO_3	Prediction of fate and transport of pollutants in the environmental matrices.
CEO_4	Overview of application of generic models of air and water quality.

Course Title: ECOTECHNOLOGY FOR ENVIRONMENT MANAGEMENT

Course Code: EMGE 618 **L-04** **Credits – 04**

Course Objectives:

CO_1	To provide a basic understanding on the systems approach and ecological modelling.
CO_2	To provide knowledge about Ecotechnology, the underlying principles and applications.
CO_3	To provide knowledge about various ecologically sound restoration approaches based on case studies.
CO_4	To make the student understand application of ecotechnology in industry.

UNIT-I **12 Hrs.**

Systems approach and Ecosystem Modelling: Systems Theory: Basic principles in relation to ecosystems; Ecosystem cybernetics and feedback mechanisms; Ecosystem stability- resistance and resilience; Resource apportionment models and stability. Ecological modeling - Matrix Model, Compartment model, System transfer functions, mathematical and statistical models for ecological and resource management

UNIT-II **12 Hrs.**

Ecotechnology for Sustainable growth: Definition of Ecotechnology, Differences between environmental engineering and ecological engineering; Ecological engineering principles; Ecosystem principles governing ecotechnology; Application of Ecotechnology for sustainable development and societal welfare; Tools and applications of ecotechnology; Concept of Buffer zones; Green belts; Ecosystem dynamics; Ecological footprints

UNIT-III **12 Hrs.**

Ecotechnological applications for polluted and degraded systems: Concept of ecorestoration: principles and approaches, Eco-restoration of Riparian zone, mined area; Rehabilitation of salt-affected and water-logged lands. Phytoremediation of polluted sites: rhizofiltration, phytoextraction, phytostabilisation, phytotransformation, Soil stabilisation, Vermitechnology.

UNIT-IV **12 Hrs.**

Ecotechnological applications for Industrial waste management: Balancing inputs and outputs of materials and energy in industries, Life cycle planning, Eco-designing and eco-efficiency; Cradle to cradle approach for waste management. Constructed Wetland (CW) technology: different types of CWs, applications in wastewater treatment, mechanisms of N and P removal, role of macrophytes & microbes, Important macrophytes.

Suggested Readings and References:

1. Mitsch, W.J. and. Jørgensen, S.E. (1989). Ecological Engineering: An Introduction to Ecotechnology, John Wiley and Sons, Inc. New York
2. Jørgensen, S.E. (2012). Introduction to Systems Ecology. CRC Press/ Taylor & Francis
3. Kangas, P.C. (2004). Ecological Engineering: Principles and Practice. Lewis Publishers, CRC Press, Florida
4. Mitsch, W.J. and. Jørgensen, S.E. (2004). Ecological Engineering and Ecosystem Restoration" John Wiley and Sons, Inc., New York

5. Cairns Jr., J. (Ed.), 1994. Rehabilitating Damaged Ecosystems, Vol I. CRC Press

6. Robert H. Kadlec and Scott Wallace. (2005). Treatment Wetlands, 2nd Ed. CRC Press

Course Expected Outcomes:

CEO_1	The students will develop a systemic approach.
CEO_2	The students will learn the principles and application of ecotechnology tools.
CEO_3	The students will learn basic and applied approaches to restore various types of polluted and environmentally degraded systems in eco-friendly manner.
CEO_4	The students will learn the latest eco-efficient approaches to be used in industry to promote sustainable development.

Course Title: ENVIRONMENTAL BIOTECHNOLOGY

Course Code: EMGE 620 **L-04** **Credits – 04**

Course Objectives:

CO_1	To provide knowledge of environmental biotechnology to students
CO_2	To provide knowledge on xenobiotics and their biodegradation
CO_3	To impart in-depth knowledge on bioremediation and phytoremediation of polluted environments.
CO_4	To make them learn about role of microbes in sustainable energy production and bioethical issues in using genetically engineered systems.

UNIT I **12 Hrs.**

Introduction: Definition and importance of Environmental biotechnology, Biosensors in detection of environmental pollutants**:** Biomarkers, Biosensors of pollution- BOD, ammonia, methane. Role of microbes in sequestering carbon dioxide, Role of biotechnology in conservation of species**:** *in-situ* and *ex-situ* conservation through gene banks.

UNIT II **12 Hrs.**

Biodegradation: Recalcitrance of xenobiotics, Biodegradation of Halogenated hydrocarbons, Substituted aromatic compounds, Polycyclic aromatic hydrocarbons, Pesticides, Surfactants. Emerging Environmental Biotechnologies**:** Application of microbial enzymes, Biomembrane reactors.

UNIT III **12 Hrs.**

Bioremediation of polluted environments: Environmental applications of bioremediation, types of bioremediation, mechanisms of microbial metal resistance and detoxification, microbial removal of radioactive elements, bioremediation of oil spills, limitations of bioremediation, bioremediation and genetic engineering. Biotechnology and radioactive pollution**:** Bioleaching; Biosorption and Bio-depollution of soils contaminated by radio elements. Phytoremediation: Phytoremediation of xenobiotics and bioaccumulation of metals using plants.

UNIT IV **12 Hrs.**

Development of biodegradable and eco-friendly products: Fermentation technology; biomass production; Biofuel and Biodiesel-plant derived fuels, bioethanol, biohydrogen; biofertilizers; biopesticides; bio-polymers. Bioethics in Environmental biotechnology**:** Bioethics issues - Genetically engineered microbes and GM Crops.

Suggested Readings and References:

1. A. Scragg. (2005). Environmental Biotechnology, 2nd Edition, Oxford University Press.
2. B. Rittman, P. L. McCarty. (2000) Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill.
3. I. S. Thakur. (2006). Environmental Biotechnology: Basic Concepts and Applications. I K International Publications.
4. B.C. Bhattacharya and R. Banerjee (2007). Environmental Biotechnology. Oxford University Press.

5. G. Bitton. (1999). Wastewater Microbiology, 2nd Ed., Wiley-Liss, New York.
6. J. M. Lynch, A. Wiseman. (1998). Environmental Bio-monitoring: The Biotechnology Ecotoxicology Interface, Cambridge University Press.

Course Expected Outcomes:

CEO_1	The students will understand the basic concepts and scope of environmental biotechnology.
CEO_2	The students will learn about the role of microbes in degradation of recalcitrant compounds.
CEO_3	The students will get knowledge about potential applications of microbes and plants in remediation of toxic environment.
CEO_4	The students will learn about the role of microbes in development of environment – friendly products.

Course Title: AQUATIC ECOSYSTEMS AND WETLAND MANAGEMENT

Course Code: EMGE 622 **L- 04** **Credits – 04**

Course Objectives:

CO_1	The purpose of this course is to improve students understanding of the physical, chemical, and biological components of aquatic ecosystems including lakes, rivers, streams, wetlands, and marine
CO_2	Be familiar with the basic principles of hydrodynamics, biology and biogeochemistry as they relate to the science and management of aquatic ecosystem.
CO_3	Develop an understanding of how diverse disciplines approach are required for the study of freshwater and marine ecosystems in the context of classical as well as contemporary research.
CO_4	Demonstrate how landscape concepts are being applied for conservation and restoration of aquatic ecosystems. The role of GIS and remote sensing to devise strategies for the study of a contemporary problem in aquatic ecosystems.

Unit I Ecology of Aquatic ecosystems **12 Hrs.**

Definitions: Fresh water (lentic, and lotic), marine and wetland ecosystems, classification of aquatic ecosystems; chemical composition of fresh and marine waters. Major environmental (abiotic and biotic) factors and ecosystem processes; Energy flow in aquatic ecosystems; Water quality and pollution of lakes, reservoirs, rivers, and marine waters; Aquatic Invasive species. Nutrient dynamics, methanogenesis, carbon cycle, climate change and impact on aquatic ecosystems

Unit II Fresh water ecosystems **12 Hrs.**

Lakes and reservoirs: Stratification and zonation in lakes; Community organization, productivity, trophic levels and food webs; Bioassessment and bio-criteria in lakes and reservoirs, index of biological integrity, eutrophication and trophic state index; biological adaptations, Wetlands: Soil types and redox potential; Ecology of constructed wetlands.

Rivers: Types of rivers, geomorphology, longitudinal profile and classification of drainage network, rivers and ecological continuum, riparian and flood plain wetlands; river biodiversity, community organization; trophic structure and food webs; energy flow

Unit III Marine & Estuarine ecosystems **12 Hrs.**

Structure and function of marine ecosystems; Case I & II waters, estuary types and genesis; organisms (plants, animals, microbes) in various ecological zones, community organization, productivity, upwelling and downwelling of nutrients; mangroves, coral reefs; Biodiversity in Arctic and Antarctic oceanic environment.

Unit IV Aquatic biodiversity, ecosystem services and restoration **12 Hrs.**

Landscape ecological concepts; ecological restoration of fresh water and coastal ecosystems.

Coastal regulation zone, International conventions& protocols: Ramsar Convention, Convention

on Biological Diversity, Ramsar sites in India. Remote sensing and GIS in aquatic ecosystem management, biodiversity conservation, climate change and aquatic ecosystem response.

Suggested Readings and References:

1. Singh, G. K. and Nautial, K. C. 2009. Biodiversity and Ecology of Aquatic Environment. Narendra Publishing House
2. Mitsch, W.J. and Gosselink,J.G. 2015. Wetlands, 4th edition, John Wiley & Sons. 744p.
3. Keddy, P. A. 2010. Wetland Ecology: Principles and Conservation. Cambridge University Press, 516p.
4. Dodds, W. K. 2002. Fresh Water Ecology-Concepts and Environmental Applications, Academic Press.
5. Castro, Pand Huber, M.E. 2003. Marine Biology. 4th Edition. Mc-Graw Hill.
6. Allan, J.D. and M.M. Castillo. 2007. Stream ecology: structure and function of running waters. 2nd Edition. Springer, NY.

Course Expected Outcomes:

CEO_1	Upon completion of this course students will be able to reliably demonstrate understanding of how aquatic ecosystems function, analyze and interpret limnological data, and apply limnological information to surface water management.
CEO_2	Explain how physics, biology, geology and nutrient cycles interact in aquatic ecosystem.
CEO_3	Students will be able to communicate effectively with the community of aquatic scientists, managers and policy makers
CEO_4	Students will identify the skills required to understand and address aquatic ecosystem management challenges.

Course Title: GEOSPATIAL TECHNOLOGY FOR ENVIRONMENT MANAGEMENT

Course Code: EMGE 624 **L-04** **Credits – 04**

Course Objectives:

CO_1	To appraise the students about the wide applicability of Geospatial technology in the spheres of environment management.
CO_2	To make aware the utilities and characteristics of different satellite series working in the fields of meteorology and resource management.
CO_3	To give inside knowledge about conservation and management strategies of bio resources and urban studies using remotely sensed data. Environment Impact Assessment studies using RS and GIS would be another important objective of the subject.
CO_4	To study the applications of Geospatial technology in different disaster types and utilities of it in various phases of disaster management.

UNIT I **12 Hrs.**

Land and Water Resource Management: Satellite missions for weather forecasting, monitoring and for conservation and management of natural resources. Remote sensing for mapping of origin and formation of different landform types - denudational, fluvial and coastal landforms. Assessment of soil degradation and desertification. Soil erosion vulnerability modelling. Remote sensing applications in air, surface and subsurface water resources evaluation, concept of hydrogeomorphological mapping and identification of ground water prospect zones.

UNIT II **12 Hrs.**

Bioresources Management and EIA: Remote sensing applications in agriculture, forest resources, afforestation activities, forest density mapping, issues in forest management. Forest fire modelling, wildlife mapping and habitat suitability assessment, carbon sequestration; wetland conservation and management; marine bioresources. Geospatial techniques in EIA and EMP preparation. Environmental assessment of ecologically disturbed areas. Mining impacts on land and bio-resources. Water and Air Pollution studies.

UNIT III **12 Hrs.**

Urban Resource Management: Urban land use mapping, built environment, transportation network, utility-facility mapping, urban sprawl studies, site selection for urban development, Urban Information System. Urban Heat Island assessment and mitigation.

UNIT IV **12 Hrs.**

Disaster Management: Identification of suitable remote sensing data for disaster management studies. Studies related to landslides, earthquake, mining, volcanic, glacial and coastal hazards with case studies. Decision Support System for Disaster Management. Preparation of contingency planning during disasters and elements at risk mapping for urban disasters using earth observation

data.

Suggested Readings and References:

1. George Joseph. 2005. Fundamentals of Remote Sensing. University Press (India) Ltd. Hyderabad.
2. John, R. Jensen. 2009. Remote Sensing of the Environment: An Earth Resource Perspective. Dorling Kindersley (India) Pvt. Ltd., NOIDA, India.
3. Davidson, Donald A. 1998. Soils and Land Use Planning, Longman, London.
4. A. Ganesh. 2006. Application of Geospatial Technology. Satish Serial Pub. House, Delhi.
5. Colwell, Robert W. 1971. Monitoring of Earth Resources from Aircraft and Spacecraft, NASA. Washington D.C.
6. Ester, J. and Senger, L.W. Tayler. 2001. Remote Sensing Techniques for Environment Analysis.

Course Expected Outcomes:

CEO_1	After completing the course students will enable to understand the contributions of Geospatial technology in the diverse fields of environment.
CEO_2	Students will understand the utilities of Geospatial technology in the fields of earth, water and bio resources management.
CEO_3	For impact assessment studies students will be highly benefitted while utilising this subject.
CEO_4	The subject will help the students how this technology can be useful in studying different phases of disaster management and possible ways to reduce the risk.

Course Title: WATERSHED MANAGEMENT

Course Code: EMGE 626 **L-04** **Credits – 04**

Course Objectives:

CO_1	To introduce the concept of watershed, Govt. policies and guidelines for watershed management.
CO_2	To introduce the importance of watershed characteristics and its ecosystem services.
CO_3	To impart the knowledge about watershed hydrology, its components and rainfall-runoff relationship.
CO_4	To introduce and understand watershed planning and implementation of Govt. guidelines and policies in the watershed management programs for the conservation of environment.

UNIT I **12 Hrs.**

Watershed Definition and Scope: Watershed- Concept, watershed delineation from topographical maps, watershed problems, geo-morphological characteristics of watershed, types and function of watershed, principles of watershed management, objectives of watershed management and development, agents of watershed change, watershed management programme in India, common Govt. guidelines and policies for watershed development.

UNIT II **12 Hrs.**

Watershed characteristics: Landuse, vegetation, drainage, drainage morphometry, climate, soil, geology, slope and aspect, land capability classification, types of erosion, estimation of soil loss, Universal Soil Loss Equation (USLE), Revised Universal Soil Loss Equation (RUSLE), soil conservation, ecosystem services of watershed.

UNIT III **12 Hrs.**

Watershed Hydrology: Concept of hydrology, hydrological cycle and its components; geohydrology, hydrometeorology, measurement and analysis of precipitation data, evapotranspiration, surface run-off; rainfall-runoff relationship, stream flow estimation, concept of hydrograph; sediment load, types and methods of measurement, water harvesting and conservation methods.

UNIT IV **12 Hrs.**

Watershed Planning and Management: Multi objective planning, watershed restoration, community participation, landuse practices, watershed prioritization, watershed management approaches and strategies, integrated watershed development, Components of watershed management, project implementation, monitoring and evaluation of watershed management, economics of watershed protection, climate change adaptation and mitigation in watershed, impacts and management of natural hazards, Jal Jeevan Mission of GoI

Case studies: Success stories of watershed management in India

Suggested Readings and References:

1. Singh, Rajvir. 2000. Watershed Planning and Management. Yash Publications.
2. Maitra, M.K. 2019. Watershed Management A Compendium for Field Practitioners
3. Rajora, Rajesh 2019. Integrated Watershed Management. Rawat Publication, Jaipur.
4. Common Guidelines for Watershed Development Projects-2008 Revised Edition – 2011. National Rainfed Area Authority Planning Commission Government of India
5. Jim Smyle, Crispino Lobo, Grant Milne, and Melissa Williams 2014. Watershed Development in India an Approach Evolving Through Experience. Agriculture and Environmental Services
6. Operational Guidelines for the Implementation of Jal Jeevan Mission (Har Ghar Jal). Ministry of Jal Shakti Department of Drinking Water and Sanitation National Jal Jeevan Mission. 2019

Course Expected Outcomes:

CEO_1	Students will be able to learn about the importance of Govt guidelines and policies about the watershed management.
CEO_2	Students will be able to acquire the knowledge about the role of various watershed characteristics and their importance in watershed conservation.
CEO_3	Students will be able to learn about the different methods of rainfall, streamflow measurements and sediment load estimation.
CEO_4	Students will be able to acquire the knowledge about systematic approach of land and water conservation methods and implementation of Govt. policies for sustainable watershed management for the conservation of environment.

Course Title: ESSENTIALS OF URBAN FORESTRY AND BIODIVERSITY

Course Code: EM 628 **L-04** **Credits – 04**

Course Objectives:

CO_1	To understand the role of forestry and biodiversity in urban green space planning.
CO_2	What are the various scope and opportunity to improve biodiversity through forestry activities in urban landscape?
CO_3	The status of biodiversity in urban areas of India and other countries. Understanding the threats of urban biodiversity and conservation strategies.
CO_4	Case Studies from various important cities of India in reference to development of urban forestry for ecological and social contribution of biodiversity.

UNIT I **12 Hrs.**

Concepts: Urban greens, landscape, urban forestry and biodiversity, Indian and global perspectives of urban forestry. Human dimensions of urban forests - Migration, Urban poverty and livelihood. Environmental problems in urbanizing world. Ecological, social, economic, health, cultural, recreation values of urban green space. Benefits of linking forest and vegetation with urban planning. Contribution of urban forests in generating livelihoods for urban poor in India. Concept of sustainable cities, Smart cities and green space.

UNIT II **12 Hrs.**

Urban biodiversity: Floral and faunal diversity in urban landscape. Urban trees and shrubs. Threats and significance of Urban biodiversity in India. Characteristics of selected urban forestry species. Significance of biodiversity parks. Design wildlife habitat. Climate change affect and urban vegetation. Preparation of urban biodiversity register (UBR). Monitoring the loss of Urban Biodiversity. Strategy for Urban biodiversity planning, conservation and development.

UNIT III **12 Hrs.**

Management of urban forest landscape: Urban landscape elements. Species choice for Urban forestry. Technical aspects of tree maintenance-pruning, cleaning, post plantation care, cleaning, nursery, water management. Types of plantation, design & tree architecture, monitoring, urban forestry management issues, stake holder's analysis.
Case study of Urban area restoration- waterbody and wasteland.

UNIT IV **12 Hrs.**

Urban forestry planning policy and application: Integration of urban forestry in city planning, institution policy and social issues, incentives and partnerships. Role of government, NGOs, corporate houses and civil society organizations in urban green space development, Public, private partner (PPP) model.
Case study of Urban Green Space Management in Cities-New Delhi, Hyderabad, Bangalore
Synthesis and directions for future research, planning and implementation in urban forestry and biodiversity.

Suggested Readings and References:

1. Grey, G.W., and F.J. Denke. (1986). Urban Forestry. Wiley Publication.
2. Miller, R.W. (1997). Urban Forestry: Planning and Managing Urban Green Spaces, 2nd edition. Prentice Hall.
3. Konjendijk, et al. (2005). Urban Forests and Trees. Springer.
4. Kuchelmeister, G. (1998). Urban Forestry in the Asia – Pacific Region: Status and Prospects. APFSOS Working Paper #44, Food and Agriculture Organization.
5. Bradley, Gordon A., (editor) Urban Forest Landscapes: Integrating Multidisciplinary Perspectives.

Course Expected Outcomes:

CEO_1	Understanding overall issues of urban ecosystem and mitigation of pollution through urban plantation measures.
CEO_2	Understanding various types of urban landscape and measures to maintain urban biodiversity. Assessment of urban biodiversity and their contribution to human health and environment.
CEO_3	Student will be able to understand how to improve urban landscape through management of forestry and biodiversity with the contribution of various stake holders.
CEO_4	Overall understanding about the role of forestry and biodiversity in urban green space planning.

Course Title: ENVIRONMENTAL MICROBIOLOGY LAB

Course Code: EM 652 **P-04** **Credits – 02**

Course Objectives:

CO_1	To provide hands on training and practical skills to students in areas comprising basic environmental microbial technology
CO_2	To train the students to isolate and cultivate the microorganisms in laboratory conditions
CO_3	To impart training to students for determining presence of microbes in various environmental samples and further characterization.
CO_4	To make them understand and learn how to use microbes for various environmental applications.

LIST OF EXPERIMENTS

S. No.	Name of the Practical
1.	To study the sterilization techniques and Introduction to various types of laboratory equipments used to isolate & maintain microbes and Microscopes.
2.	To prepare nutrient agar and nutrient broth media and agar slants & agar plates for the culture of microorganisms.
3.	To isolate microbial colonies present in a mixed culture by streak plate methods & to obtain a pure culture.
4.	To determine the rate of growth of bacteria in liquid media.
5.	To prepare a culture of soil micro-organism & count the number of bacterial colonies.
6.	To identify microbial specimen using permanent slides.
7.	To prepare the culture of waste water micro-organism and to enumerate them.
8.	Removal of azo dye by using *Phanerochaete chrysosporium*.
9.	To perform differential staining between the two principal groups of bacteria.
10.	To determine the presence of coliform bacteria in a given water sample using MPN Method.
11.	Bioremediation of phenol from wastewater.
12.	To study soil microbial respiration with different conditions
13.	To study the working of double chamber Microbial Fuel Cell

Suggested Readings and References:

1. I.L. Pepper and C.P. Gerba (2004). Environmental Microbiology: A Laboratory Manual. 2nd Edition, Elsevier Academic Press.
2. H.W. Seeley, P.J. Vandemark, J.J. Lee (1990). Microbes in Action: A laboratory Manual of Microbiology 4th edition, W. H. Freeman.

3. M.J. Pelczar, E.C.S. Chan, N.R. Krieg (1998). Textbook of Microbiology 5th edition Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4. Basic Practical Microbiology- A manual. (2006) Society of General Microbiogy, UK.
5. Alan Scragg (2005). Environmental Biotechnology, 2nd Ed., Oxford University Press.

Course Expected Outcomes:

CEO1	The students will be able to prepare sterilized culture media and culture the microbes in laboratory under aseptic conditions.
CEO2	The students will be able to enumerate, isolate, purify and characterize microbial strains.
CEO3	The students will learn to isolate microbes from different environmental samples.
CEO4	The students will learn how to apply microbes for bioremediation of environmental pollutants and energy recovery.

Course Title: AIR AND WATER POLLUTION LAB

Course Code: EM 654 **P-04** **Credits – 02**

Course Objectives:

CO_1	The practical course is aimed to provide knowledge about air emissions and various techniques of analysing air pollutants.
CO_2	The practical course is designed to impart knowledge about various physico chemical parameters of water & their analysis using different instruments and method of measuring noise.
CO_3	To enable students to learn health impacts of environment pollutants and various standards fixed bythe pollution control board for management of environment pollution.

LIST OF EXPERIMENTS

1. To study principle, components and working operation of respirable dust sampler.
2. Determination of NOx from ambient air using Respirable dust sampler/High volume sampler.
3. Determination of level equivalent values at a given place using Sound Level Meter.
4. Determination of Sox from ambient air using Respirable/High volume sampler
5. Determination of RPM & TSPM from ambient air using Respirable dust sampler.
6. Estimation of chlorides in water sample by Mohr's method.
7. Determination of Chemical Oxygen Demand (COD) in waste water.
8. Determination of Biological Oxygen Demand (BOD) of waste water.
9. Estimation of Sulphate in water sample by spectrophotometric method.
10. Estimation of Phosphate in water sample by spectrophotometric method.
11. To study principle, components and working operation of stack monitoring kit.
12. Estimation of Nitrate in water sample by spectrophotometric method.
13. Estimation of Fluoride in water sample by SPADNS method.
14. Estimation of Total Solids and Total Dissolve Solids in water sample
15. Determination of Total Kjheldahl Nitrogen
16. Estimation of Nickel, lead and copper in water samples by AAS.
17. Determination of the concentration of Oil & Grease in given water sample.

Suggested Readings and References:

1. Singal, S. P. (2000). Noise Pollution and Control, Narosa Publishing House, New Delhi
2. Sudha Rani (2001) Laboratory Manual on Engineering Chemistry, Dhanpat Rai Publishing Company, New Delhi
3. Peavy, H. S., Donald, R. R., Tchobanoglous, George. (2013). McGraw Hill Education (India) Private Limited, Chennai
4. Maria Csuros (1997) Environmental sampling and analysis Lab Manual, CRC Press.
5. Satinder Ahuja (2013) Monitoring Water Quality, Pollution Assessment, Analysis, and Remediation, Elsevier
6. APHA (2005), Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association.

Course Expected Outcomes:

CO_1	The course will provide necessary information and practical knowledge about the noise, air and water quality parameters to check their current status in environment.
CO_2	Students will be able to learn about types, sources and impacts of noise, air and water pollutants.
CO_3	Course will help them to learn about the analytical techniques and to handle different instruments in laboratory.

Course Title: FIELD VISIT/ INDUSTRY VISIT – REPORT/ PRESENTATION

Course Code: EM 656 **Credits – 02**

Course Objectives:

CO_1	The main objective of field/ industry visit is to link the classroom knowledge and real-world situation.
CO_2	To expose students to practical field exposure in the diverse fields of environment such as bio-resources, natural hazards (earthquake/ landslide destruction), wetlands, biodiversity, natural resource management, environmental pollution, industrial visit, etc.
CO_3	To expose students about the ground truth data collection using remote sensing maps of various environmental parameters directly from the field and primary data collection using self-prepared structured questionnaires.
CO_4	To give the idea how data collected from the fields can be compiled and represented in report and presentation modes.

The field/industry visit is the first opportunity for the students in the programme to get real world exposure about different aspects of environment. These visits are arranged in different parts of the country to get diverse practical experiences. In the process they are introduced with environmental issues, bio-resources, natural hazards, wetlands, biodiversity, natural resource management, environmental pollution, different industries etc., which are covered in their M.Sc. (Environment Management) programme. During the field visits the students would also get opportunities to verify class room lectures by interacting and visualizing field specialized faculties/ scientists of various government, educational and research institutions.

The students will be evaluated based on the analysis, interpretation, compilation and presentations of the topics assigned to them individually or in group. Student needs to present individually for assessment. An internal committee formed by the Dean USEM comprised of the faculty members of the School will assess the performances.

Course Expected Outcomes:

CEO_1	Students will get exposure to different environmental issues in ground scenarios.

CEO_2	Students will be confidant how filed data can be collected using field instruments and scientific methods.
CEO_3	Maps prepared using satellite imagery in the laboratory can be validated in the fields using GPS and other instruments.
CEO_4	Student will be able to compile the data collected from the fields and represent it in report and power-point presentation modes.

THIRD SEMESTER

Course Title: ENVIRONMENTAL IMPACT ASSESSMENT & RISK ANALYSIS

Course Code: EM 701 **L-04** **Credits – 04**

Course Objectives:

CO_1	To introduce the purpose, scope and guidelines of EIA.
CO_2	To acquaint with the EIA methods and impacts on biotic and abiotic environment.
CO_3	To familiarize with the mitigating and monitoring methods and economic valuation of environment components.
CO_4	To introduce the concept of environment risk analysis and assessment.

UNIT I **12 Hrs.**

Introduction, basics & baseline: Scope and development of EIA; NEPA,1969; Objectives and basic principles and types of EIA; Strategic environmental assessment (SEA); EIA Gazette Notification,1994 & 2006-Category A,B Projects, Environment clearance (EC) requirements and stages. General EIA methodology; Establishing the environmental baseline; Screening & scoping in EIA; Siting Criteria & guidelines; prohibited zones; Identification of Valued Environmental Components (VEC).

UNIT II **12 Hrs.**

Impact identification, prediction & Evaluation: Impact identification -Checklists, matrices, qualitative methods, networks and overlay maps; Impact prediction- prediction models for impacts on air, water, soil and biological environment, Impact evaluation -multi attribute utility theory, environmental evaluation system- Cost benefit analysis, Economic valuation of intangible environmental impacts, Social impact assessment.

UNIT III **12 Hrs.**

Impact mitigation, monitoring & audit: Mitigation methods and approaches, Appraisal, Review, Decision making, Public participation, monitoring and auditing in EIA process, various forms of audit, Environment management plan (EMP), Environmental Impact Statement (EIS), Post-clearance Monitoring Protocol.

Case studies: EIA of thermal power plant, Pulp and paper mill, river valley project, mining project, urbanization and linear development.

UNIT IV **12 Hrs.**

Risk analysis and Environment management: Fundamentals of hazard, Definition of risk, environmental risk analysis, exposure and risk assessment, basic steps in risk assessment, hazard identification, dose response assessment, risk characterization, quantified risk assessment for industrial accidents, design of risk management program, risk assessment application to environmental management problems: Human and environment assessment of post-combustion CO_2 capture from amine based solvents, DOWs Fire and Explosion Index.

Suggested Readings and References:

1. John Glasson, Riki Therivel and Andrew Chadwick. 2005. Introduction to Environmental Impact Assessment, 2nd Ed., UCL Press, Philadelphia, USA
2. Canter, Larry W. 1996. Environment Impact Assessment. McGraw-Hill.
3. Y. Anjanvelu. 2002 Environmental Impact Assessment Methodologies, B.S.Publications,
4. D. P. Lawrence, 2003. Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley and Sons.
5. Eccleston, C.H. 2011. Environmental Impact Assessment, Taylor & Francis
6. Peter Wathem 2013. Environmental Impact Assessment: Theory and Practice, Taylor & Francis

Course Expected Outcome:

CO_1	Students will be able to understand the need, purpose and regulation of EIA.
CO_2	They will be equipped with the understanding of various EIA methods.
CO_3	They will be exposed to practical implications from specific EIA case studies.
CO_4	They will be able to carry out risk assessment and analysis.

Course Title: ECOSYSTEM MANAGEMENT AND RESTORATION

Course Code: EM 703 **L-04** **Credits – 04**

Course Objectives :

CO_1	To enable students for better understanding of ecosystem dynamics.
CO_2	To empower them to take appropriate judicious and appropriate decision with regards to restoration of degraded ecosystem.
CO_3	To learn various tools and techniques in restoration of degraded ecosystem.
CO_4	To enable students to carry out restoration activities in future.

UNIT I **12 Hrs.**

Ecosystems degradation and restoration needs: Overview of ecosystem ecology, ecosystem disturbances and degradation; Ecosystem services *vis a vis* ecosystem biodiversity and functions; importance of ecological restoration; trajectory of ecosystem restoration; Dimensions in restoration ecology-species, communities, ecosystems, landscapes; succession and restoration.

Landscape elements and ecosystems: Island biogeography theory; patch, matrix and corridor model of landscapes; scale, heterogeneity, patterns; fragmentation; flows between landscape elements and ecosystems.

UNIT II **12 Hrs.**

Ecosystem Management for restoration: The Economics of Ecosystems and Biodiversity (TEEB); ecosystem integrity and health; Ecosystem management- principles, guidelines and applications; ecosystem approach for environment management; Geospatial techniques in ecosystem management.

UNIT III **12 Hrs.**

Restoration tools and techniques: Planning and implementation framework; adaptive management and monitoring; steps for restoring an ecosystem; prioritization of restoration actions: restoring and maintaining ecosystem services- soil ecology, biological diversity, hydrology, habitat loss, watersheds; measurement of restoration success.

UNIT IV **12 Hrs.**

Application of ecological restoration techniques to: Lakes and wetlands; Rivers, streams and floodplains; Urban areas; Coastal ecosystems; Forest ecosystems; Mining sites and ecologically disturbed areas; Desertic and degraded soils; biodiversity conservation; animal restoration and reintroduction; sustainable development; climate change and ecosystem restoration.

Suggested Readings and References:

1. D. Matlock, Robert A. Morgan (2011). Ecological engineering design: restoring and conserving ecosystem services, John Wiley & Sons, Inc, 339p.
2. Martin R. Perrow, Econ and Anthony J. Davy [Ed] (2002), Handbook of Ecological Restoration, Volume 1 and 2, Cambridge University Press.
3. Sven Erik Jorgensen [Ed] (2009). Applications in Environmental Engineering, Elsevier

B.V. Radarweg, Amsterdam, The Netherlands, 380p.

Ecological Restoration (2008). A Source Book for Ecological Restoration, Foundation for Ecological Security, 104p.

4. Pirot, J.-Y., Meynell P.J. and Elder D. (2000). Ecosystem Management: Lessons from Around the World. A Guide for Development and Conservation Practitioners. IUCN, Gland, Switzerland and Cambridge, UK. x + 132 pp.
5. Jelte van Andel and James Aronson (editors) (2006). Restoration ecology: the new frontier, Blackwell Publishing, 319p

Course Expected Outcomes:

CEO_1	Outgoing students will be fully empowered with clear idea and concept of ecosystem functions.
CEO_2	Graduated students can work as restoration managers and practitioners.
CEO_3	They will be empowered to apply various techniques in restoration processes.

Course Title: INDUSTRIAL POLLUTION PREVENTION AND CONTROL

Course Code: EM-705 **L - 03** **Credits – 03**

Course Objectives:

CO_1	The purpose of this course is to demonstrate how an environment professional can protect the environment from the potentially deleterious effects of industrial activities using various pollution prevention options and treatment technologies.
CO_2	It aims to provide students understanding and learning of basic manufacturing processes and sources of waste generation in industries.
CO_3	To provide knowledge on harmful impacts of various industrial pollutants and conventional methods of treatment of these pollutants.
CO_4	The students will be able to learn about application of different technologies for wealth recovery and treatment of industrial wastes. This will also help them to design scheme for treatment of different types of industrial wastes on the basis of their characteristics.

UNIT I **9 Hrs.**

Types of industrial pollutants, Industrial wastewater characterization, List of green, orange and red industries, Standards of disposal of industrial wastes, Industrial Estate planning.
Methods of volume and strength reduction, Process and equipment modification, Segregation, Reuse, Recycle, Good housekeeping practices, Conservation, Adoption of cleaner production technologies, Neutralization, Equalization, Proportioning.

UNIT II **9 Hrs.**

Specific treatment technologies: Oil and Gas removal, Cyanide removal, Nitrogen and phosphorus removal, VOCs removal.
CETP: Requirement and objectives of CETP, Planning and management of CETP facilities for small-scale industries, Institutional deficiencies, Current scenario of CETPs in Delhi-A case study.

UNIT III **9 Hrs.**

Manufacturing process description, Waste/emission generation sources, Waste characteristics, Pollution prevention options and treatment for the following industries:

1. Sugar
2. Distillery
3. Pulp and Paper
4. Tannery
5. Dairy

UNIT IV **9 Hrs.**

Manufacturing process description, Waste/emission generation sources, Waste characteristics, Pollution prevention options and treatment for the following industries:

1. Fertilizer
2. Oil Refineries
3. Cement
4. Textile
5. Pharmaceutical

6. Iron and Steel

Suggested Readings and References:

1. Ecrenfelder W.W. (1990), Industrial Pollution Control, McGraw Hill Int. Ed.
2. Metcalf & Eddy Inc. (2002). Wastewater Engineering Treatment and Reuse 4th Ed. Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. Nemerow, N. L. (1978). Industrial Water Pollution: Origin, Characteristics and Treatment. Addison- Wesley Publishing Company, New York.
4. Patwardhan, A. D. (2012) Industrial Waste Water Treatment, PHI Learning Pvt. Ltd. New Delhi.
5. Khitoliya, R. K. (2014) Environmental Pollution: Management and Control for Sustainable Development. 2nd Ed. S. Chand publication, New Delhi
6. M. N. Rao and A. K. Dutta (…) Wastewater Treatment , 3rd Edition, Oxford & IBH Publishing Co Pvt.Ltd.
7. CPCB Publications

Course Expected Outcomes:

CEO_1	The students will be able to understand the types of industrial pollutants and importance of their toxic effects if discharged untreated which will make them aware of environmental concerns.
CEO_2	The students will understand the importance of methods of volume and strength reduction and adoption of cleaner technologies to reduce pollution load.
CEO_3	The students will understand the concept and importance of Common Effluent Treatment Plant.
CEO_4	The students will get in-depth knowledge on manufacturing processes/basic operations of various major Indian industries along with types, sources, characteristics and environmental impacts of waste generated.

Course Title: ENVIRONMENTAL HEALTH AND SAFETY

Course Code: EM 707 **L-03** **Credits – 03**

Course Objectives:

CO_1	The course is designed to impart knowledge and understanding of health risks associated with environmental and safety failures.
CO_2	Course will help students to understand and learn about sustainable health programmes initiated worldwide.
CO_3	To understand regulatory requirement and their implementation to ensure health safety at workplace.
CO_4	To recognize and explore approaches towards safe and healthy environment.

UNIT I Environment Health 9 Hrs.

Basic Principle and history of Environment Health, Definition and dimensions, Indicator of health, Health Programme in India, Physical response of man to Environmental stressors, Biogeochemical factors in environmental health, epidemiological issues- goitre, fluorosis, arsenic poisoning, Global Health Programmes.

UNIT II Causes and effects of pollution 9 Hrs.

Industrial Toxicology- Study of environmental dose effect relationships. Assessment of toxicity and threshold limits; health hazards associated with some important industries; Occupational health hazards: Pneumoconiosis, Silicosis, Anthracosis, Asbestosis. Hazards associated with radiological environment; natural and man-made radiations; Acute and delayed cellular effects by radiation, radiation syndromes, chromosomal aberrations.

UNIT III Transmissible diseases 9 Hrs.

Symptoms, epidemiology and control of vector borne diseases- amoebiasis, trypanosomiasis, filariasis, leishmaniasis, schistosomiasis. Waterborne diseases: Jaundice &diarrhea. Principles of toxicology: Toxic chemicals in the environment and their effects: effects of heavy metals, Pesticides. Mode of entry of toxic substances, biotransformation of xenobiotics, indices of toxicology. LD50: Definition and uses, Dose response curve, Carcinogens and Mutagens.

UNIT IV Environment Health Management 9 Hrs.

Health ecology, Analysis and recommendations regarding health and safety problems in the working and living environment with Biostatistics and epidemiological analysis.

Occupational and industrial hygiene technology- illustrating the principles, methods of recognizing evaluating and controlling environmental hazards, Health and safety policies: Occupational Safety and Health Act, Introduction to ILO, Factories Act (1948), Safety Standards, Role and responsibilities of different organisations in environment health and safety management.

Suggested Readings and References:

1. R.B. Phillip., (1995).Environmental Hazards and Human Health. CRC Press Inc., Boca Raton, Florida.
2. M.T. Morgan., (2002). Environmental Health.3rd ed., Brooks Cole Publication.
3. J.E. Park and K. Park, (1986). Textbook of Preventive and social Medicine, Banarsidas Bhanot publication.
4. R. Niesink,M. A. Hollinger, J. De Vries., (1996). Toxicology – Principles and Applications, CRC Press.
5. K.T. Narayanan, (2015). Safety, Health and Environment Handbook, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
6. K. Herman and M. Bisesi., (2002). Handbook of Environmental Health and Safety, Vol II, Ed. 4, Lewis Publishers, CRC Press, Washington DC.

Course Expected Outcomes:

CO_1	Environment Health & Safety course will provide necessary information and knowledge about the various aspects in the field of safety, Health and environment.
CO_2	Students would be able to learn theory and principle of various national and international health programmes and policies implemented all over the world.
CO_3	Students will be able to understand and learn about hazardous chemicals, various pathogens & their life cycle, route of entry into human body as well as short term and long term hazards to individual health & safety and environment.
CO4	Regulatory requirements play an important role in health and safety management of workers in industries. By learning this course students would be able to gain factual knowledge of regulations and their requirement at the work place.

Course Title: ENVIRONMENTAL INSTRUMENTATION

Course Code: EM 709 **L-03** **Credits – 03**

Course Objectives:

CO_1	To introduce the fundamental concepts of analytical techniques.
CO_2	Promote fundamental understanding of various spectroscopy and chromatographic techniques.
CO_3	Application of the knowledge of these techniques in spectrophotometers and Atomic absorption spectrophotometer.
CO_4	Application of chromatographic techniques in HPLC and GC.

UNIT I **9 Hrs.**

Photometry: Introduction to Chemical Instrumentation analysis, Advantages over classical methods, Classification; Spectro, Electro analytical and Seperative methods, Solution preparation: Concept of Normality , Molarity , Molality and percentage , Laws governing Photometry : Beer's and Lambert's Law; Limitations of Lambert's Beer's law; Origin of absorption spectra; Colorimeters: Standard series and balancing method of determination Spectrophotometers(UV-Visible), Monochromators, filters, grating, prisms, Single wavelength and single beam monochromatic systems , Dual wavelength and double beam monochromatic system

UNIT II **9 Hrs.**

Flame and Atomic Absorption Spectrophotometer: Flame photometry; Principle, Elementary Theory, Construction details, fuel gases, atomiser, burner, optical system, recording system. Atomic absorption spectrophotometer; Theoretical concepts, Instrumentation, Hollow cathode lamps, Burners and flames, optical and electronic systems; Non-Flame techniques; Background correction methods in AAS; Spectral and Chemical interference in AAS

UNIT III **9 Hrs.**

Fundamentals of Chromatography: General description, definition, terms and parameter used in chromatography; Linear and Column chromatography; Theories of elution chromatography; Measures of column efficiency; Column resolution; Classification of chromatographic methods, criteria for selection of stationary and mobile phase nature of adsorbents, Rate theory, Methodology for selection of stationary phase, Quantitative and qualitative analysis by Chromatography

UNIT IV **9 Hrs.**

HPLC AND GC: High pressure liquid chromatography; Apparatus, Pumps, Column packing, Characteristics of liquid chromatography, detector; UV, IR, Refractometer and fluorescence detector. Gas Chromatography; Principle, Comparison of GSC and GLC, Columns packed and tubular; Study of detectors; Thermal conductivity, Flame ionisation, Electron capture; Factors affecting the separation and various separating applications; Statistical evaluation of measurement data and uncertainty estimation.

Suggested Readings and References:

1. D.A. Skoog,(2000), Principles of Instrumental analysis, fifth edition , Saunders college publication
2. D.H.Williams and J.Fleming (1995). Spectroscopic methods in organic chemistry, Sixth edition , McGrawHill
3. B.K. Sharma (2007), Instrumental methods of chemical analysis, Krishna Prakash Media
4. J.Willard. (1999). Instrumental methods of analysis,7th Edition , CBS publishers
5. Arun Bahl and B. S. Bahl (2016) , Advanced Organic Chemistry, S. Chand
6. J. Mendham (2009) ,Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition

Course Expected Outcomes:

CEO_1	Shall be able to learn the principle and theory of analytical techniques.
CEO_2	Shall have fundamental understanding of the chemistry-based instrumentation.
CEO_3	Will know the methodology of selection of analytical techniques.
CEO_4	Learn about the basic operation of various instruments like Spectrophotometer, AAS, GC and HPLC.

Course Title: ENTREPRENEURIAL MINDSET

Course Code: USMS 112 **P-02** **Credits – 02**

Course Objectives:

CO_1	To provide a foundation for basic entrepreneurial skills and to acquaint them with the world of entrepreneurship and inspire them to set up and manage their businesses.
CO_2	To acquaint students with the process of creativity and innovation
CO_3	To expose students to various aspects of entrepreneurship and business
CO_4	To expose students to case studies on successful entrepreneurs

Unit I: Introduction: The Entrepreneur; Theories of Entrepreneurship; Characteristics of successful entrepreneurs, myths of entrepreneurship; entrepreneurial mindset- creativity (steps to generate creative ideas, developing creativity) and innovation (types of innovation) **7 Hrs.**

Unit II: Promotion of a Venture and Writing a business plan: Opportunity Analysis; External Environment Analysis Economic, Social and Technological Analysis. Business plan- What is business plan, parts of a business plan. Writing a Business Plan. **7 Hrs.**

Unit III: Entrepreneurship Support: Entrepreneurial Development Programmes (EDP): EDP, Role of Government in Organizing EDPs. Institutions supporting small business enterprises: central level, state level, other agencies, industry associations. **7 Hrs.**

Unit IV Practicals:

- Presenting a business plan
- Project on Startup India or any other government policy on entrepreneurship
- Discussion on why startup fails, role of MSME etc.
- Discussion on role of entrepreneur in economic growth.
- Discussion on technology park.
- Case study discussion on successful Indian entrepreneurs.

Suggested Readings and References:

1. Charantimath (8th Ed., 2014), Entrepreneurship Development and Small Business Enterprise, Pears Education.
2. Bamford C.E (1st Ed 2015), Entrepreneurship: A Small Business Approach, McGraw Hill Education.

3. Hisrich et al. (2013) Entrepreneurship, McGraw Hill Education
4. Balaraju, Theduri (2012), Entrepreneurship Development: An Analytical Study, Akansha Publishing House.
5. David, Otis, (2014), A Guide to Entrepreneurship, Jaico Books Publishing House, Delhi.
6. Kaulgud, Aruna, (2012), Entrepreneurship Management, Vikas Publishing House, Delhi.
7. Chhabra, T.N. (2014), Entrepreneurship Development, Sun India.

Course Expected Outcomes:

CEO_1	Students form a foundation for basic entrepreneurial skills
CEO_2	Students understand creativity and innovation for opportunity recognition
CEO_3	Students learn abo opportunity analysis and writing a business plan
CEO_4	Students are inspired by examples of successful entrepreneurs.

Course Title: ECOLOGY AND ECOSYSTEM RESTORATION LAB

Course Code: EM 751 **P-04** **Credits – 02**

Course Objectives:

CO_1	To equip students with practical knowledge of assessment of ecosystem health.
CO_2	To understand the ecosystem integrity and importance of restoration.
CO_3	To provide practical and field experience of restoration sites.
CO_4	To take appropriate decision towards restoration of degraded ecosystem in future.

A. Inside the campus

1. Monitoring site characteristics
2. Using GPS receiver
3. Population and density estimation
4. Sampling technique for various parameters of vegetation and animals
5. Community structure and vegetation indices
6. Soil analysis
7. Studies on Hydrophytic plants and functional groups
8. Biomass assessment

B. Field Visit to any one or two eco-restoration sites and short report as a case study: (Yamuna biodiversity Park, Aravali biodiversity Park, Asola Bhati Sanctury, Hauz Khas Lake, Tilpath Valley Biodiversity Park, Kamla Nehru Biodiversity Park, Okhla Bird Sanctuary, etc).

Suggested Readings and References:

1. D. Matlock, Robert A. Morgan (2011). Ecological engineering design: restoring and conserving ecosystem services, John Wiley & Sons, Inc, 339p.
2. Martin R. Perrow, Econ and Anthony J. Davy [Ed] (2002), Handbook of Ecological Restoration, Volume 1 and 2, Cambridge University Press.
3. Sven Erik Jorgensen [Ed] (2009). Applications in Environmental Engineering, Elsevier B.V. Radarweg, Amsterdam, The Netherlands, 380p.
4. Ecological Restoration (2008). A Source Book for Ecological Restoration, Foundation for Ecological Security, 104p.
5. Pirot, J.Y., Meynell P.J. and Elder D. (2000). Ecosystem Management: Lessons from Around the World. A Guide for Development and Conservation Practitioners. IUCN, Gland, Switzerland and Cambridge, UK. x + 132 pp.
6. Varah, F., Mahongnao, M., Khasimwo, P. and Shimrah, T. (2020). Environmental Studies. Heritage Publishers. New Delhi.

Course Expected Outcomes:

CEO_1	The graduated students will better understand the ecosystem monitoring processes.
CEO_2	The graduated students will be able to take independent decision on matters related to various restoration projects in future.

Course Title: ENVIRONMENTAL INSTRUMENTATION LAB

Course Code: EM 753 **P-04** **Credits – 02**

Course Objectives:

CO_1	Introduce students to the elemental theory of analytical instrumentation.
CO_2	Explain the basic principle of photometric and chromatographic techniques involved.
CO_3	Usage of spectroscopy and chromatography techniques in analytical instruments.
CO_4	Correct operation of various instruments.

LIST OF EXPERIMENTS

1. Determination of trace metals such as Calcium in aqueous sample using Atomic Absorption Spectrometer.
2. Determination of trace elements in aqueous sample using Flameless or graphite furnace Atomic Absorption Spectrometer.
3. Determination of carbon content in soil samples through CHN analyser.
4. Determination of sulphur content in organic samples through CHN analyser.
5. Analysis of organic contaminants using Gas Chromatograph and interpretation of data.
6. Reverse phase chromatography -HPLC.
7. Normal Phase chromatography – HPLC.
8. Metal analysis using double beam UV-VIS spectrophotometer.
9. Determination of Na and K using AAS.

Suggested Readings and References:

1. Fssai manual of methods of analysis of food, water, (2015). Ministry of Health and Family Welfare, GOI, New Delhi.
2. Trivedi, P.R., (2007). Environmental water and soil analysis, Akashdeep Publishing House.
3. APHA (2005), Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association.
4. Singh, D., Chhonkar, P.K., Dwivedi, B.S., (2005). Manual on soil plant and water analysis. Westville Publishing House.
5. CPCB, Guide manual: water and wastewater analysis.
6. Keith, L.H., (1996). Compilation of EPA's Sampling and Analysis Methods, 2nd ed. Lewis Publ./CRC Press, Boca Raton, Fla.

Course Expected Outcomes:

CEO_1	Student shall be able to prepare various standard and sample solutions.
CEO_2	Shall be able to determine and decide the appropriate technique to be used for analysis.
CEO_3	Shall understand the correct operation of the taught instruments.
CEO_4	Shall be able to understand the limitations of each of these technique and the alternatives available.

Course Title: SUMMER TRAINING REPORT & PRESENATATION (EVALUATIVE)

Course Code: EM 755 **Credits – 02**

Course Objectives:

CO_1	To give the basic exposure to the students in professional environment.
CO_2	To give the students an opportunity to work in relevant industry/organizations outside the University.
CO_3	To give basic ideas to carry out a specific the research.
CO_4	To give opportunity to work in a team.

The summer internship is an opportunity for the students to interact with the industry and reputed organizations working in the diverse fields of environment. Student get exposure to work in live projects and professional environment. Completing the summer internship is primarily student's responsibility. They should consult with supervisor/s and faculty moderator early in the process to make sure the goals considered are appropriate and feasible for research. After completion of the summer training students have to defend their summer internship in front of faculty members.

Course Expected Outcomes:

CEO_1	Students will get the exposure in real professional environment.
CEO_2	In addition to learning the specialized skills of a particular field students also will improve skills in communication, teamwork and computer proficiency that will help them during their 6-month dissertation.
CEO_3	The summer internship will also help the students to motivate in which field they will select in their future research.

Course Title: CLIMATE CHANGE MITIGATION & ADAPTATION

Course Code: EMOE 731 **L-04** **Credits – 04**

Course Objectives:

CO_1	To introduce the concepts and science of climate change and its effects on various ecosystems.
CO_2	To introduce basics of climate models and to aware students about various techniques of carbon sequestration and management to overcome the problem of climate change.
CO_3	To impart knowledge about climate change & its impacts assessment and Indian response to various climate issues.
CO_4	To introduce and understand international protocols, treaties and conventions on climate change and Indian commitment for international agreements.

UNIT I **12 Hrs.**

Basic concepts and mechanisms: Define weather and climate**,** Science of climate change, global warming, radiative balance, energy budget, El-Nino and La Nina, greenhouse gases in the atmosphere – sources, levels and mechanisms of action. **Effects:** Rise in earth's temperature; effects on forests, agro-ecosystems; desertification, freshwater ecosystems, sea level rise; melting of polar ice and glaciers; rainfall patterns; extreme events, socio-economic and public health consequences, climate change effects on migration, impact of black carbon on climate and feedback mechanism.

UNIT II **12 Hrs.**

Climate Change Policy-Mitigation: Earth's carbon reservoirs and carbon cycle, Carbon storage and sequestration, carbon management through biotic sequestration-forests, wetlands; soil carbon sequestration oceanic and geologic injection, scrubbing and mineral carbonation; bio fuels, carbon farming and carbon trading

UNIT III **12 Hrs.**

Climate Change Policy – Adaptation: Climate change impact assessment – applications for agriculture, vulnerability assessment; economics of adaptation, measurement of adaptation cost; issues in financing adaptation; case studies; **Indian scenario**: Projected impact of climate change in India; temperature, rainfall, forests, agriculture, water resources; India's response to climate change; National Action Plan on climate change;

UNIT IV **12 Hrs.**

International response: Intergovernmental Panel for Climate Change (IPCC) and its role; United Nations Framework Convention on Climate Change (UNFCCC), CDM and Kyoto Protocol; Bali road map; The Copenhagen Accord; future actions; ethics of climate change, key aspects of Paris Agreement, India's actions vis-a-vis international programmes, National Determined Contribution (NDC) Targets of India for 2030.

Suggested Readings and References:

1. Dieter Helm (2020), Net Zero: how we stop causing climate change, William Collins publication.
2. Egbert Boeker and Rienk van Grondelle (2013). Environmental Science- Physical Principles and Applications, John Wiley & Sons, Ltd.,New York
3. AkimasaSuni, Kensuke, F., and Ai, Hiramatsu.(2010). Adaptation and mitigation strategies for climate change. Springer.
4. Burroughs, W.J. (2007). Climate change: A multidisciplinary approach (2nd edition.). Cambridge University Press. Dash,
5. Sushil Kumar. (2007). Climate change: An Indian perspective. Cambridge University Press India. New Delhi.
6. IPCC,(2007): Summary for policymakers. In: Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK, 7-22.

Course Expected Outcomes:

CEO_1	Students will be able to learn and understand the concept of climate change and its impacts on various ecosystems.
CEO_2	Students will be able to get knowledge about various carbon sequestration techniques for better management of climate.
CEO_3	Students will be able to learn about impacts related to climate change and Indian response to climate change.
CEO_4	Students will be able to enhance their knowledge about international and national programmes and their importance in climate change.

Course Title: DISASTER RISK REDUCTION AND MANAGEMENT

Course Code: EMOE 733 **L-04** **Credits – 04**

Course Objectives:

CO_1	To provide a holistic knowledge about triggering of disaster, its vulnerability and risk assessment.
CO_2	To understand the disaster management cycle, damage assessment, recovery and reconstruction-before, during and after disaster.
CO_3	To understand the disaster risk reduction tools and capacity building to minimize the impact.
CO_4	To introduce and understand disaster management processes for Disaster Risk Reduction (DRR) in our country.

UNIT I **12 Hrs.**

Introduction: Concepts and definitions of hazard, disaster, vulnerability, resilience, and risks; Inter relationship between hazard, vulnerability and disaster risk, Factors affecting vulnerabilities, classification of disasters; brief introduction of Geological/Natural Disasters (earthquakes, landslides, tsunami, mining), Hydro-Meteorological Disasters (floods, cyclones, lightning, thunderstorms, hail storms, avalanches, droughts, cold and heat waves); Biological Disasters (epidemics, pest attacks, forest fire); Technological Disasters (chemical, industrial, radiological, nuclear) and Man-made Disasters (building collapse, rural and urban fire, road and rail accidents); Global Disaster Trends – Emerging Risks of Disasters; Issues and Impact of Climate Change on disasters, Gender and social issues during disasters, Relevance of indigenous knowledge and appropriate technology.

UNIT II **12 Hrs.**

Disaster Management Cycle, Risk Reduction and managing risks: Disaster Management Cycle; Principles of risk management, hazard and vulnerability mapping and analysis (physical, social, organizational, economical, technological). Developmental projects (dams, power plants etc.) and risk management; Evacuation, Communication, Search and Rescue; Emergency Operation Centre – Incident Command System; Relief and Rehabilitation; case studies of risk management. Post-disaster Damage and Needs Assessment; Restoration of Critical Infrastructure; Recovery and Reconstruction.

UNIT III **12 Hrs.**

Disaster Risk Reduction tools and capacity building: Prevention and Mitigation of Disasters, Early Warning System; Disaster Communication Systems (Early Warning and Its Dissemination); Preparedness, adaptive ecosystems management for disaster risk reduction; awareness during Disasters; Geoinformatics in Disaster Management (RS, GIS, GPS); Land Use Planning and Development; Disaster safe designs and constructions; Structural and Non Structural Mitigation of Disasters; Role of print and electronic media during disasters. Community based disaster risk reduction. Health issues and hospital preparedness and response; System approach in disaster management; Disasters and Ecosystems: Climate change and ecosystems-based management for

disaster risk reduction and resilience, policies for disaster preparedness program, preparedness, planning roles and responsibilities.

UNIT IV **12 Hrs.**

Disaster Management in India: Disaster Management in India; Disaster Management Act 2005; National Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter-Governmental Agencies; National Disaster Management Authority (NDMA); NIDM (National Institute of Disaster Management), State Disaster Management Authorities, State Disaster Response Force (SDRF), National Disaster Response Force (NDRF), Prime Minister National Relief Fund (PMNRF), Chief Minister Relief Fund and role, Institutional arrangement during disasters; International Agencies (International Space Charter, UNISDR); International Strategy for Disaster Reduction; Hyogo Framework (2005-2015); Sendai Framework (2015-2030); S&T Institutions for Disaster Management in India.

Case studies: Bhopal gas tragedy, Gujarat earthquake, Indian cyclones, Uttarakhand disasters, COVID – 19, Other major disasters of India. etc.

Suggested Readings and References:

1. Bimal Kanti Paul (2011)**.** Environmental Hazards and Disasters-Contexts, Perspectives and Management, John Wiley & Sons, 332p.
2. Fabrice G. Renaud, Karen Sudmeier-Rieux and Marisol Estrella (Ed) (2013). The role of ecosystems in disaster risk reduction, United Nations University Press.
3. Jack Pinkowski (Ed.) (2008). Disaster Management Handbook, CRC Press -Taylor & Francis Group, 595p.
4. Joseph F. Gustin (2010). Disaster & Recovery Planning: A Guide for Facility Managers, 5th Edition, Taylor &Francis., 436p.
5. Yacov Y. Haimes (2009). Risk Modeling, Assessment and Management, Third Edition, A John Wiley & Sons, Inc. Publication, 1033p.
6. Publications of National Disaster Management Authority (NDMA), and National Institute of Disaster Management (NIDM).

Course Expected Outcomes:

CEO_1	Students will be able to understand the fundamental causes, vulnerability and risk assessment and consequences of disasters. After going through the course The integration of knowledge, our Govt policies and instructional framework would be very helpful in minimizing the disaster risk reduction in all vulnerable locations.
CEO_2	Students will be able to get the knowledge about the utility and importance of disaster management cycle.
CEO_3	Students will be able to learn how capacity building and risk reduction tools are important in disaster management.
CEO_4	Students will be able to understand about the significance of Disaster Risk Reduction and management (DRR), role of different Government institutions for the benefit of natural resource management and society.

Course Title: URBAN BIODIVERSITY STRATEGIES FOR CONSERVATION

Course Code: EMOE 735 **L-04** **Credits – 04**

Course Objectives:

CO_1	The students will be taught about how cities have evolved as a Novel Ecosystem and a human dominated Biome.
CO_2	They will get an insight about its biodiversity, species and communities and how are they different from wild counterparts.
CO_3	To apprise them of evolving strategies to conserve urban biodiversity.
CO_4	They will learn the importance of urban biodiversity for the physical, mental and spiritual well being of human society.

Unit I The Urban Ecosystem **12 Hrs.**

Introduction to the Urban Ecosystem as a Novel Ecosystem in Anthropocene; Definition of Urban, Urbanization, Anthropocene; Introduction to Urban Ecology; Global and Local Patterns of Urbanization: Exo-urbanization, Suburbanization, Disurbanization, Reurbanization, Slums, Shanty Towns; Causes of Urbanization; Urban climate; Heat Island Effect.

Unit II Urbanization, Anthromes and Biodiversity **12 Hrs.**

Introduction of Cities as human biomes / Anthromes; Impacts of Urbanization on Biodiversity (positive,negative,extinction), , Biotic Homogenization and Differentiation; Biodiversity in urbanized areas:; Urban Species and Communities: Native Species , Non-native species Urbanophilics, Urbanophobics, Synanthropes, Archaetypes, Neotypes, Impacts of Non-native/invasive/exotic species ;Urban Ecosystem Services.

Unit III Biodiversity Conservation Strategies in Urban Areas **12 Hrs.**

Urban planning and green infrastructure: Green roofs; Green spaces; Urban Parks , Gardens and Landscaping; Living walls; Vertical Gardening ; Singapore/City Biodiversity Index, Biophilic Cities, Resilient Cities, Sustainable Cities ,Cities and Sustainable Development Goals; Green Delhi Movement in NCT of Delhi.

Unit IV Urban Biodiversity and Human Well Being **12 Hrs.**

Urban Biodiversity for human health and well being, Diseases in Urban Environment, Urban Biodiversity and Conservation Education; Conservation and Society, Motivations for Conserving Urban Biodiversity, Future Strategies for Urban Biodiversity, Cities and Convention on Biodiversity and Conservation; National Biodiversity Strategy and Action Plan, Local Biodiversity Strategy and Action Plan.

Suggested Readings and References:

1. Lugo A.E., Winchell K.M. and Carlo T.A. 2018. **Novelty in Ecosystems**. In: Dominick A.,

Della Sala, and Michael I. Goldstein (eds.) **The Encyclopedia of the Anthropocene**, vol. 3, Pp. 259-271. Oxford: Elsevier.

2. Hobbs, R. J., Higgs, E. S.and Hall,C. M.2013. **Novel ecosystems: intervening in the new ecological world order.** John Wiley & Sons, Chichester, UK.
3. Pickett, S.T.A. and J.M. Grove. 2009. Urban Ecosystems: What would Tansley Do? Urban Ecosystems 12: 1-8.
4. Gilbert OL. 1989. **The Ecology of Urban Habitats**. London: Chapman and Hall.
5. Ellis, E.C. 2013 Sustaining biodiversity and people in the world's anthropogenic biomes. *Current Opinion in Environmental Sustainability*, 5:368–372.
6. Hughes J., Pretty J., Macdonald D.W. (2013). Nature as a source of health and well-being: is this an ecosystem service that could pay for conserving biodiversity? In: **Key Topics in Conservation Biology** (eds. D.W. Macdonald, K.J. Willis). John Wiley & Sons Ltd, Chichester, UK.

Course Expected Outcomes:

CEO_1	The students would be able to understand how and why world is getting urbanized.
CEO_2	They will learn about the urban species and communities and their relationship with the human beings and how they have adapted different habitats within human dominated biomes.
CEO_3	They would be able to understand that in urban planning, environment, biodiversity and their conservation should be substantially incorporated for cities to be sustainable and biophilic.
CEO_4	They will become learned professionals to inculcate the need of nature, motivate and educate the urban Society for their well being.

Course Title: HUMAN ASPECTS OF BIODIVERSITY AND ENVIRONMENT

Course Code: EMOE 737 **L-04** **Credits – 04**

Course Objectives:

CO_1	In the present era when we are witnessing global pandemic and moving towards 6th extinction, this course will provide an insight about various human dimensions of biodiversity and environment.
CO_2	To appreciate the existence of socio-cultural diversity and its role in biodiversity conservation.
CO_3	To bring awareness on various conservation related initiatives and polices being implemented by government and NGOs on local/ national/ international level.
CO_4	To arrive at conscious decision related to ethical issues related to use/treatment of bioresources.

Unit I Linking biodiversity, environment and human being **12 Hrs.**

Basic concept of biodiversity and environment: Biotic and abiotic factors, biodiversity and its components; How biodiversity and environment affects human well-being: case studies from historical perspectives and current scenario; Factors that affect human perceptions about biodiversity and environment

Unit II Understanding human aspects of biodiversity and environment **12 Hrs.**

Socio-cultural diversity, ethnic diversity, linguistic diversity; Sacred groves and sacred landscapes; Understanding ecological services; Understanding how local biodiversity and environment affects human life (wrt local plants and animals, pesticide use vs agricultural pests, handling native vs. exotic sp.). Understanding different missions related to human aspects of biodiversity and environment: 'Swachh Bharat Abhiyan', 'Clean Ganga'and 'Clean-Yamuna'campaign,'Save Tiger', 'Save Vulture', 'Save Forest', 'Protect Wetlands'.

Unit III Concepts and applications wrt human aspects of biodiversity and environment **12 Hrs.**

Concept of Indigenous Knowledge Management and benefit sharing with case studies; Biomimicry; Ecotourism and Eco-taxation; Eco-designing, Conservation education, Environmental journalism

Unit IV Addressing issues related to human aspects of biodiversity and environment **12 Hrs.**

Ethical issues related to biodiversity and environment; Pro and cons of ban on animal dissection; Issues related to GM crops and Vertebrate pest management; Practising sustainability for a better future

Suggested Readings and References:

1. Miller, G.T. and Spoolman, S. 2011. Living in the Environment. Cengage Learning.

2. Pearce, D.W. and Moran, D. 1994. The Economic Value of Biodiversity. Earthscan Publishers.
3. Wood, P.M. 2000. Biodiversity and Democracy: Rethinking Society and Nature. University of British Columbia Press.
4. Groom, M.J., Meffe, G.R. and Carroll, C.R. 2006. Principles of Conservation Biology. Sinauer Associates, Inc., USA.
5. Primack, R. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc.

Course Expected Outcomes:

CEO_1	To make conservation professionals informed citizens about various dimensions of human activities impacting biodiversity/ environment that will enable them to actively participate and contribute in various capacities to reduce/mitigate such impacts through direct participation in conservation related activities at grassroot level or policy making.
CEO_2	To address the linkages between environment, biodiversity and mankind for a healthy and sustainable local/ national/ global ecosystem that will make proper understanding of the gap areas where environmentalist/conservationist has to play a role and find/create job opportunity.

Course Title: SUSTAINABLE ECOTOURISM

Course Code: EMOE 739 **L-04** **Credits – 04**

Course Objectives:

CO_1	What is the concept and principle of ecotourism? Various ecological, economics and social dimension of ecotourism.
CO_2	How ecotourism is classified? What are the various policy and practices available to support ecotourism in India?
CO_3	How carrying capacity of destination is assessed?
CO_4	What are the global experiences of ecotourism from practicing world?

UNIT I **12 Hrs.**

Concept of Ecotourism: Definitions, ecotourism, difference between tourism, examples various forms, development of ecotourism in India and outside. Ecological, social and economic dimensions of ecotourism, eco-tourists, linkages with local culture, ethics and livelihoods, stakeholders' analysis, threats due to large scale ecotourism.

UNIT II **12 Hrs.**

The ecotourism perspectives: High value may also be high impact, bulk ecotourism and problems, stakeholder challenges. Ecotourism Policy and practices, national policy frame work, example – Madhya Pradesh &Uttarakhand State case. Successful ecotourism initiative, Criteria and Indicators for sustainable Ecotourism. Ecotourism certification, Accreditation of eco-lodges and resorts .

UNIT III **12 Hrs.**

Ecotourism alternative services and Ecotourism Products: sustainable extraction, extraction impacts, community involvement and compensation, shift from consumption to sustainable management. Concept of carrying capacity and factors. Designing ecotourism products and their relevance to ecology and livelihood, benefit sharing, capacity building of locals.

UNIT IV **12 Hrs.**

Case studies and analysis: Ecotourism in protected areas of India and abroad,

- Mangrove area and biodiversity conservation through ecotourism,
- Ecotourism in coastal areas
- Mountain area ecotourism in Sikkim
- Herbal ecotourism in Kerala,
- Wildlife area ecotourism.

Suggested Readings and References:

1. Honey, Martha. 2008. Ecotourism and Sustainable Development: Who Owns Paradise? 2nd edition. Island Press.

2. Jennifer Louise Hill, Tim Gale 2005 Ecotourism and Environmental Sustainability: Principles and Practice. Ashgate Publishing Company. USA
3. Patterson, Carol, Delia Owens, and Mark Owens. 2007. The Business of Ecotourism. Trafford Publishing.
4. Collier, Paul and Anthony J.J. Venables. 2011. Plundered Nations? Successes and Failures in Natural Resource Extraction. Palgrave MacMillan.
5. Seema Bhat & Syed Liyakhat 2008. Ecotourism Development in India: Communities, Capital and Conservation published by CEE, Ahmedabad.

Course Expected Outcomes:

CEO_1	Student will understand, what is ecotourism how it is different from mass-tourism?
CEO_2	What are the challenges in ecotourism implementation? Understanding the role of stakeholders in ecotourism.
CEO_3	How ecotourism practices help to improve biodiversity conservation and livelihood promotion for the society?
CEO_4	Understanding ecotourism implementation prospect through case studies from field.

FOURTH SEMESTER

Course Title: DISSERTATION ABSED SEMINAR AND PROGRESS REPORT

Course Code: EM 752 **Credits – 04**

Course Objectives:

CO_1	To inculcate the idea about the field of research.
CO_2	To give an idea how a research plan is formulated based on the problems of the study.
CO_3	To give exposure how various literature reviews are utilized to develop the objectives of the study using appropriate methods.
CO_4	To teach the students how to manage time in completing each objective. of the

The dissertation is the final stage of a Masters' degree and provides the opportunity for the students to show what they have gained during their previous semesters about the necessary skills and knowledge in order to organize and conduct a research project. It will demonstrate the students in identifying an area suitable for research based on the interest and literature review studies, setting research objectives, develop methods. Students will be allotted internal supervisor for proper guidance and they should keep regular contacts with the internal mentor. Besides there will be external guide/s if students work in outside University organization or industry. This will be evaluated in the initial phase of the semester.

Course Expected Outcomes:

CO_1	Students will get the idea how a research plan can be prepared based on the problem of the study.
CO_2	Students will be confident how to go about the research based on the research proposal (Synopsis).
CO_3	Students will get the idea how a final dissertation can be prepared including the components of the research proposal.

Course Title: DISSERTATION AND VIVA VOCE

Course Code: EM 754 **Credits – 22**

Course Objectives:

CO_1	To apply the ideas proposed (Synopsis) in the study.
CO_2	To select the appropriate materials and method to achieve all the objectives of the study.
CO_3	To give students a base how different data generated (primary) and collected (secondary) are interpreted and presented in scientific ways.
CO_4	To make the students confident in compiling all the analysis/ interpretations they made and bring them in a report form with more scientific ways.

The Master dissertation is the testimony of any student. This semester which is completely dedicated to research works will reflect what students have learned during their previous semesters. This semester will demonstrate the students in identifying suitable area for research based on the interest and literature reviews, setting research objectives, develop materials and methods, generation and collection of data and their interpretations, compilation and preparation of the final dissertation report. This phase will be the stepping stone for the students for their future endeavors. Students will also be motivated to carry out future research. This phase is important for the students where they will learn to work individually as well as in a team. Writing and presentations skill will enhance during this semester in a big way.

Course Expected Outcomes:

CO_1	Students will be able to know how proposed objectives can be implemented by selecting appropriate materials and methods.
CO_2	Students will get real filed exposure about the subjects they have studied all the years and their applicability.
CO_3	The students will have opportunity to develop professional writing skills in the form of scientific research article based on their works during the period.
CO_4	Besides, this semester will give the students confidence in carrying out any research of their interest individually as well as in a team.