SCHEME A2: M.Sc. ENVIRONMENTAL SCIENCE

(w.e.f. Academic Session 2024-25)SEMESTER – I

Course Code	Course Title	Course ID	L (Hrs)	T (Hrs)	P (Hrs)	L Credits	T Credits	P Credits	Total Credits	MARKS TI	MARKS TE	MARKS PI	MARKS PE	MARKS Total
Core Course(s)														
CC-A01	Ecology & Biodiversity & Lab I (Ecology)	241/EVS/ CC101	03	00	02	03	00	01	04	25	50	05	20	**100**
CC-A02	Environmental Chemistry & Lab II (Environmental Chemistry & Analysis)	241/EVS/ CC102	03	00	02	03	00	01	04	25	50	05	20	**100**
CC-A03	Air and Noise: Pollution and Abatement & Lab-II	241/EVS/ CC103	03	00	02	03	00	01	04	25	50	05	20	**100**
Discipline Specific Elective Courses (Select any one course from the following)														
DSE-01	Bio-statistical methods and Data Analysis & Lab I OR Ecological Restoration & Lab I	241/EVS/ DS101	02	00	02	02	00	01	03	15	35	05	20	**75**
Multidisciplinary Course(s)														
MDC-01	One from the Pool	241/EVS/ MD101	03	00	00	03	00	00	03	25	50	00	00	**75**
Ability Enhancement Course(s)														
AEC-01	One from the Pool		02	00	00	02	00	00	02	00	50	00	00	**50**
Value-added Course(s)														
VAC-01	One from the Pool	241/EVS/ VA101	02	00	00	02	00	00	02	00	50	00	00	**50**
Total Credits									**22**					**550**

L - Lecture; T-Tutorial; P - Practical

SCHEME OF M.Sc. ENVIRONMENTAL SCIENCES

(w.e.f. Academic Session 2024-25)SEMESTER - II

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A04	Environmental Geosciences & Lab III	241/EVS/CC204	03	00	02	03	00	01	04	25	50	05	20	**100**
CC-A05	Water Pollution and Control Technologies & Lab III (Water and Soil Analysis)	241/EVS/CC205	03	00	02	03	00	01	04	25	50	05	20	**100**
CC-A06	Instrumental Techniques for Environmental Analysis & Lab IV (Air and Noise: Sampling and Analysis)	241/EVS/CC205	03	00	02	03	00	01	04	25	50	05	20	**100**
Discipline Specific Elective Courses (Select any one course from the following)														
DSE-02	Environmental Microbiology and Biotechnology & Lab IV OR Environment Health and Safety & – Lab IV	241/EVS/DS202	02	00	02	02	00	01	03	15	35	05	20	**75**
Multidisciplinary Course(s)														
MDC-02	One from the Pool	241/EVS/MD202	03	00	00	03	00	00	03	25	50	00	00	**75**
Ability Enhancement Course(s)														
AEC-02	One from the Pool		02	00	00	02	00	00	02	00	50	00	00	**50**
Skill Enhancement Course(s)														
SEC-01	One from the Pool	241/EVS/SE201	02	00	00	02	00	00	02	00	50	00	00	**50**
Total Credits									**22**					**550**

Note: *internship or field training or project of 4-6 weeks during summer vacation @ 4 credits.*

SCHEME OF M.Sc. ENVIRONMENTAL SCIENCES

(w.e.f. Academic Session 2024-25)

SEMESTER - III

Course Code	Course Title	Course ID	L (Hrs)	T (Hrs)	P (Hrs)	L Credits	T Credits	P Credits	Total Credits	MARKS TI	MARKS TE	MARKS PI	MARKS PE	MARKS Total
Core Course(s)														
CC-A07	Environmental Impact assessment and Auditing & Lab V (EIA and Auditing)	241/EVS/CC307	03	00	02	03	00	01	04	25	50	05	20	**100**
CC-A08	Energy and Environment & Lab V	241/EVS/CC308	03	00	02	03	00	01	04	25	50	05	20	**100**
CC-A09	Solid and Hazardous Waste Management & Lab VI (Waste Management)	241/EVS/CC309	03	00	02	03	00	01	04	25	50	05	20	**100**
Discipline Specific Elective Courses (Select any one course from the following)														
DSE-03	Soil Science and Eco- Agriculture & Lab VI OR Environmental Issues and Legislation & Lab VI	241/EVS/DS303	02	00	02	02	00	01	03	15	35	05	20	**75**
Multidisciplinary Course(s)														
MDC-03	One from the Pool	241/EVS/MD303	03	00	00	03	00	00	03	25	50	00	00	**75**
Skill Enhancement Course(s)														
SEC-02	One from the Pool	241/EVS/SE302	02	00	00	02	00	00	02	00	50	00	00	**50**
Value added Course(s)														
VAC-02	One from the Pool	241/EVS/VA302	02	00	00	02	00	00	02	00	50	00	00	**50**
Seminars														
Seminar	Seminar	241/EVS/SEMINAR301	02	00	00	02	00	00	02	00	50	00	00	**50**
Internship/Field Activity#														
INTRSP	Industrial Visit/ Field Work and Report Writing	241/EVS/INTRSP301	02	00	00	02	00	00	04	00	50	00	00	**50**
Total Credits									**28**					**600**

 # Four credits of internship earned by a student during summer internship after 2nd semester will be counted in 3rd semester of a student who pursue 2-year PG Programme without taking exit option.

SCHEME OF M.Sc. ENVIRONMENTAL SCIENCES

(w.e.f. Academic Session 2024-25)

SEMESTER - IV

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Ability Enhancement Course(s)														
AEC-03	Manuscript Writing**/ Pool		02	00	00	02	00	00	02	00	50	00	00	**50**
Dissertation/Project Work														
Dissertation	Industrial Training/Research Project/ Dissertation	241/EVS/Dissertation401	0	0	40	0	0	20	20	00	00	100	400	**500**
Total Credits									**22**					**550**

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- I
SUBJECT NAME: ECOLOGY AND BIODIVERSITY & EVS – LAB I (Ecology)
Course code:CC-A01
Course ID: 241/EVS/CC101
NO. OF CREDITS: 4

L	T	P			
			TI	:	25
			TE	:	50
3	0	1	**PI**	:	05
			PE	:	20
			Total	:	100

NOTE: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
At the completion of this course, the learner will be able to:
CO1: Demonstrate knowledge of ecological principles operating at different levels of organization.
CO2: Understand the concepts of ecosystems and compare them with real life processes.
CO3: Analyze components of population and community ecology.
CO4: Interpret ecological and social phenomena from a biodiversity view point and develop new conservation measures on new or endangered species in a given habitat.

UNIT-I: INTRODUCTION TO ECOLOGY
Introduction: Definition, subdivisions and scope, basic concepts of ecology, Autecology and Synecology, the ecosystem concept, biotic and abiotic components; ecosystem processes-photosynthesis and decomposition; ecological pyramids, food webs, trophic levels, energy transfer, ecological efficiencies, models of energy flow. Biogeochemical cycles, gaseous and sedimentary cycles-carbon cycle, nitrogen cycle, sulphur cycle and phosphorus cycle, Man's impact on nutrient cycles.

UNIT-II: POPULATION AND COMMUNITY ECOLOGY
Population ecology: Characteristics, evolutionary strategies r and k selection; population growth and regulation, Species Interactions: Competition, mutualism, parasitism, predator-prey relations, allelopathy, behavioral ecology-a brief account.
Community structure and Organization, functional role and niche, keystone species, ecotone and edge-effect; plant-animal interaction.
Ecological Succession –concept, primary and secondary succession; concept and types of climax; changes in ecosystem properties during succession.

UNIT-III: BIODIVERSITY AND THREATS
Biodiversity, magnitude, global accumulation; levels biodiversity- species, genetic and ecosystem diversity; species diversity indices, rank abundance patterns. Threats to Biodiversity- Habitat loss,

pollution, species introduction, global climate change, overexploitation, poaching of wildlife. Rare species, genetic diversity of rare species, habitat loss and fragmentation. Extinction: mass extinction, extinction process, ecosystem degradation, over exploitation, invasive species. Human factors: social factors, economics, politics and action.

UNIT-IV: BIODIVERSITY CONSERVATION

In situ Biodiversity conservation strategies and approaches: Protected areas, biosphere resource, protected areas in India – Sanctuaries, national parks and biosphere resources.

Ex Situ Biodiversity conservation: Species management plans, captive breeding, field gene banks, seed gene banks, cryopreservation, gene banks.

National and international efforts for biodiversity conservation- CITES, Ramsar Convention, Convention on biological diversity, IPR and Patent rights.

REFERENCE BOOKS:

1. Brewer, R. *The Science of Ecology,* Sanders College Publishing Co., Tokyo, 1994.
2. Odum, E.P. *Basic Ecology,* W.B. Saunders, Philadelphia, 1983.
3. Fatik B. Mandal and Nepal C. Nandi. *Biodiversity: Concepts, Conservation and Biofuture,* Asian Books, 2013.
4. Jorgensen, Sven Erik. *Encyclopedia of Ecology.* Vol 1-5. Elsevier Publishers. Netherlands, 2008.
5. Joshi, B.D., Tripathi, C.P.M and Joshi, P.C. *Biodiversity and Environmental Management.* APH, New Delhi, 2009.
6. Joshi, P.C. and Joshi, N. *Biodiversity and conservation*. APH Publishing Co-operation, New Delhi, 2009.
7. Kohli, R. K., Jose, S., Singh, H. P. and Batish, D. R. *Invasive Plants and Forest Ecosystems.* CRC Press / Taylor and Francis, 2009.
8. Odum, E.P., Barrick, M. and Barrett, G.W. *Fundamentals of Ecology* (5th Ed). Thomson Brooks/Cole Publisher, California, 2005.
9. Rana, S.V.S. *Essentials of Ecology and Environmental Science* (5th Ed), PHI Learning Pvt. Ltd, 2013.
10. Sharma, P.D. *Ecology and Environment.* Rastogi Publications. New Delhi, 2016.
11. Smith, R.L. (1996), *Ecology and Field Biology*, Harper Collins, Ne7thw York.
12. Smith, T.M and Smith, R.L. *Elements of Ecology* (8th Ed), Benjamin Cummings, 2012.
13. Vandermeer, John H., Riddle, B.R. and Brown, J.H. *Population Ecology: First principle* (2nd Ed). Princeton University Press, 2013.
14. Singh, J.S., Singh, S.P. and Gupta, S.R. (2015). *Ecology, Environment and Resource Conservation*, S. Chand Publishing, New Delhi.

SUGGESTED WEB SOURCES:

1. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html
2. https://www.iucn.org/
3. https://www.cbd.int/
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14

MODE OF TRANSACTION: Lecture, demonstration, E-tutoring, discussion, assignments,

quizzes, case study, power point;
LMS/ICT Tools: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources.

LAB I (ECOLOGY)

COURSE OUTCOMES:
At the completion of this course, the learner will be able to:
CO1: Apply techniques for qualitative and quantitative sampling of plant diversity
CO2: Apply biochemical methods in ecological research of plant populations.
CO3: Design scientific methods/experiments to study various ecological parameters and biodiversity in laboratory/field conditions
CO4: Develop various conservation measures with the help of experimental knowledge.

LIST OF EXPERIMENTS:

1. To determine minimum quadrat size for studying vegetation in a grassland.
2. To study the community by quadrat method by determining frequency, density and abundance of different plant species present in a grassland.
3. To determine basal area and dominance of species.
4. To calculate Importance value index (IVI) of species.
5. To calculate index of diversity, richness, evenness and dominance of species.
6. To study ecology of some more exotic invasive weeds.
7. To study and enlist various biotic and abiotic components of pond and forest ecosystem.
8. To estimate chlorophyll content of plant leaves.
9. To estimate carbohydrate content in given plant sample.
10. To estimate protein content in the given sample.
11. Group Activity
12. Field visit and report submission

(Forest/desert/aquatic ecosystem – record biotic and abiotic components and interactions or visit to a biodiversity park/Herbal Garden and report submission.)

Note: This list of experiments is indicative only. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

REFERENCE BOOKS

1. Darrell Vodopich (2010). Ecology Laboratory Manual 1st Edition. McGraw-Hill Education
2. Magurran, A.E. (2003) Measuring Biological Diversity. Wiley-Blackwell
3. Misra, R. (2018). Indian manual of plant ecology. Scientific publishers
4. Stephen R. Gliessman (2014). Field and Laboratory investigations in agroecology, Third edition CRC Press.

MODE OF TRANSACTION:

Demonstration, Lecture, E-tutoring, Hands on training, discussion, assignments, Practical

M.Sc. ENVIRONMENTAL SCIENCES – SEMESTER- I
SUBJECT NAME: ENVIRONMENTAL CHEMISTRY
&
EVS – LAB II (ENVIRONMENTAL CHEMISTRY & ANALYSIS)
Course code: CC A02
Course ID: 241/EVS/CC102
NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

NOTE: 1. Nine questions will be set in all. All questions will carry equal marks.

2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV.

The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:

At the completion of this course, the learner will be able to:

CO1: Develop concepts of basic chemistry associated with the occurrence of environmental pollutants.

CO2: Understand various chemical constituents present in air and water, interactions among them and manner in which changes are brought about due to pollution.

CO3: Analyze the toxic chemical behavior in environmental.

CO4: Familiar with the latest green chemistry principle and applied in daily life for pollution reduction

UNIT-I: CHEMISTRY FOR ENVIRONMENT

Fundamental of environmental chemistry: Mole Concept, Solution chemistry, solubility product, Solubility of gases, Laws of thermodynamics: heat transfer processes, Gibbs' free energy; heat transfer processes, Chemical potential Chemical kinetics and chemical equilibrium; Electrochemistry and redox reactions. Sources of radiations. Radioisotopes and other radionuclides in the environment, unsaturated and saturated hydrocarbons.

UNIT-II: AIR & WATER CHEMISTRY

Atmospheric Chemistry: Composition of air; particles, ions and radicals in atmosphere, formation of particulate matter, Photo-chemical reactions in the atmosphere, thermal inversion, photochemical smog, acid rain, chemistry of ozone layer depletion; greenhouse gases and global warming.

Aquatic chemistry: Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, Solubility of gasses, carbonate system, redox potential.

UNIT-III: SOIL AND GEOCHEMISTRY

Soil Chemistry: Physio-chemical composition of soil, humus, Inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, Cation exchange capacity (CEC), **Environmental geochemistry**: Concept of major, trace and REE. Classification of trace elements, Solubility and mobility of trace elements; Biochemical aspects of Arsenic, Cadmium, Lead, Mercury, Carbon monoxide, O_3, PAN, MIC and other carcinogens.

UNIT-IV: GREEN CHEMISTRY AND TECHNOLOGY

Green chemistry: new trends in green chemistry, Basic principles, Atom economy concept and its environmental importance, Green reagents and Green solvents,

Green technology and synthesis process: Microwave heating, Ultrasound technique, Industrial Ecology.

REFERENCE BOOKS:

1. Manahan, S. E. (2017). *Fundamentals of Environmental Chemistry*, 10th Edition, CRC Press, USA.
2. Baird, C. and Cann, M. (2012). *Environmental Chemistry*, 5th Edition, W.H. Freeman, USA.
3. Ahluwalia, V.K, (2017). Advance Environmental Chemistry. Teri Press Publisher
4. Connell D. W. (2005). *Basic concepts of Environmental Chemistry* 2nd Edition, CRC Press, USA.
5. Harrison R M (2007). *Principles of Environmental Chemistry*, RSC Publishing, UK.
6. Girard J. (2013). *Principles of Environmental Chemistry* 2nd Edition, James & Barlett Publishers, USA.
7. Hillel, D. (2008). *Soil in the Environment: Crucible of Terrestrial Life*, 1st edition, Academic Press, USA.
8. Lancaster M. (2002). *Green Chemistry: An Introductory Text*, RSC Publishing, UK.
9. Manahan, S. E. (2006). *Green chemistry and the ten commandments of sustainability*, 2nd Edition, Chem Char Inc. Publishers, USA.
10. Manahan, S. E. (2017). *Water chemistry: green science and technology of nature's most renewable resource*, CRC Press, USA.
11. Clark J. H. and Macquarrie, D. J. (2008). *Handbook of Green Chemistry and Technology*, Wiley-Blackwell, UK.
12. Subramanian, V. (2011). A Textbook of Environmental Chemistry, New Delhi: I.K International Publishing House.

SUGGESTED WEB SOURCES:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://www.swayam.gov.in/explorer?category=Chemistry
3. https://nptel.ac.in/courses/122/106/122106030/
4. https://nptel.ac.in/courses/104/103/104103020/
5. https://ndl.iitkgp.ac.in/homestudy/science
6. https://www.slideshare.net/TstThong/environmental-chemistry-lecture

MODE OF TRANSACTION: Lecture, demonstration, E-tutoring, discussion, assignments, quizzes, case study, power point;
LMS/ICT Tools: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources.

EVS – Lab II (Environmental Chemistry & Analysis)

COURSE OUTCOMES:

At the completion of this course, the learner will be able to:

CO1: Trained in calculation and prepare the solution of various concentrations that are used in analysis.

CO2: Easy to access the quality of drinking water supply.

CO3: Trained in identification of water quality parameters and water quality analysis.

CO4: Easily handle the water quality projects and abled to solve the water quality problems.

LIST OF EXPERIMENTS:

1. To prepare the solution of different concentrations from solid and liquid chemical.
2. Determination of pH and Electrical conductivity/TDS of a given water sample
3. Determination of TS, TSS and TDS of a given water sample by gravimetric method.
4. Estimation of acidity and alkalinity of a given water sample. (Acid-base titration)
5. Determination of Total, temporary and permanent hardness of a given water sample (Complexometric titration)
6. Determination of calcium and magnesium content in given water sample (Complexometric titration)
7. Determination of chloride of a given water sample. (Precipitation titration)
8. Determination of Residual free chlorine in water sample.
9. Determination the lambda max of the given compound by using UV-VIS spectrophotometer.
10. Determination of turbidity of given water sample using Nephelometer.
11. Estimation of Sulphate in water sample by using Nephelometer/Spectrophotometric method.
12. Group activity
13. Field visit and report submission

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

REFERENCE BOOKS:

1. American Public Health Association (APHA) (2012). *Standard method for examination of water and wastewater*, 22nd edn. APHA, AWWA, WPCF, Washington.
2. Yadav, M. S. (2008). *Instrumental methods of chemical analysis*, Campus Books

International. Delhi.
3. Quevauviller, P. (2006). *Analytical methods for drinking water: Advanced in sampling and analysis*, John Wiley Publisher.
4. Patnaik, P. (2010). *Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes*, London: CRC Press.
5. Nollet, L. M. L (2007). *Handbook of water analysis*, London: CRC Press.
6. Gupta, P. K. (2009). *Methods in environmental analysis water, soil and air*, Jodhpur: Agrobios.

SUGGESTED WEB SOURCES:

1 http://moef.gov.in/
2 https://cpcb.nic.in/
3 https://www.icmr.gov.in/
4 https://bis.gov.in/

MODE OF TRANSACTION:

Demonstration, Lecture, E-tutoring, Hands on training, discussion, assignments, Practical

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- I
SUBJECT NAME: AIR & NOISE: POLLUTION & ABATEMENT & Lab-II
Course code: CC-A03
Course ID: 241/EVS/CC103

NO. OF CREDITS: 4

L	T	P			
			TI	:	25
			TE	:	50
3	0	1	**PI**	:	05
			PE	:	20
			Total	:	100

NOTE: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
At the completion of this course, the learner will be able to:
CO1: Understand the fundamentals of origin, impacts and control of different air pollutants.
CO2: Explain the types, nature and behavior of air pollutants under the influence of atmospheric conditions.
CO3: Appraise the monitoring techniques and control measures to curb the air pollution, considering the standards limits.
CO4: Understand the technical aspects of sound waves and controlling methods for vibration and noise pollution.

UNIT-I: AN INTRODUCTION TO AIR POLLUTION
Air Pollution: World and Indian scenario; Sources and classification of air pollutants; Criteria Air Pollutants and their properties; Atmospheric Aerosols; Long Range Transport of Atmospheric Pollutants; Impacts of air pollutants on health, plants and materials; The Air (Prevention and Control of Pollution) Act, 1981 and its amendments, National Air Quality Standards

UNIT-II: AIR POLLUTION MONITORING
Air pollutants sampling: Sedimentation, High-volume Filtration, Tape sampler, Impingement and Electrostatic precipitator; Collection of gaseous air pollutants: Grab sampling, Absorption in liquid, Adsorption on solids, Freeze out sampling; Indoor Air Monitoring.
Source Sampling: Representative sampling, isokinetic sampling, Flue gas analyzer principles for monitoring COx, NOx, SOx, Hydrocarbon.
Air Pollutants Dispersion and Modelling: Meteorological aspects of air pollutants dispersion, Plume behavior; Gaussian Plume Model, Line source model and Area source model.

UNIT-III: AIR POLLUTION CONTROL TECHNOLOGIES
Particulate pollutants Control: Gravitational Settling Chambers, Cyclonic separator, Fabric filter System, Electrostatic precipitators, Wet scrubbers

Gaseous Pollutants Control: Absorption; spray chambers (and towers or columns), plate or tray towers, packed towers, and venturi scrubbers; Adsorption, Pressure-Swing Adsorption (PSA), Condensation: Surface and contact condensers; Combustion: Direct-flame, thermal and catalytic combustion

Vehicular Pollution Control: Air-Fuel ratio, Catalytic convertor: Selective catalytic reduction (SCR), Selective non-catalytic reduction (SCNR), Bharat Stage Emission Standards (BSES)

UNIT-IV: NOISE POLLUTION

Definition; Sources; Decibel Scale, Sound Pressure Level, Combining Decibel, Frequency Weighting Networks, Noise Indices (L10, L50, L90, Leq, LDN, TNI). Noise & vibration measurement and noise standards, Noise control and abatement measures: Active and Passive methods, Impact of noise and vibrations on human health.

REFERENCE BOOKS:

1. Bell, L.H. and Bell, D.H., 1994. *Industrial noise control: Fundamentals and applications.* New York.
2. Cheremisinoff, N.P., 2002. *Handbook of air pollution prevention and control.* Elsevier.
3. Clarke, A.G. ed., 2012. *Industrial air pollution monitoring*. Springer Science & Business Media.
4. Rao, C.S., 2007. *Environmental pollution control engineering.* New Age International.
5. Tiwary, A. and Williams, I., 2018. Air pollution: measurement, modelling and mitigation. CRC Press.
6. Vallero, D.A., 2014. *Fundamentals of air pollution*. Academic press.
7. Wang, L.K., Pereira, N.C. and Hung, Y.T. eds., 2005. *Advanced air and noise pollution control*. Totowa, NJ, USA: Humana Press.
8. Wark, K., Warner, C.F. and Wayne T, D., 1998. *Air pollution: its origin and control*. Addison-Wesley.

SUGGESTED WEB SOURCES:

1. https://swayam.gov.in/ & https://nptel.ac.in/courses/
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
3. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html
4. http://moef.gov.in/
5. https://cpcb.nic.in/

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study. **LMS/ICT TOOLS:** Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB II:

COURSE OUTCOME:

At the completion of this course, the learner will be able to:

CO1: Explain the different methods followed for sampling and analysis of analysis of air pollutants.

CO2: Appraise the quality of air and suggest management plans to control the air pollutants.
CO3: Determine the air pollutants level in stationary sources and explain the dispersion pattern with reference to the meteorological conditions.
CO4: Assess the noise level at different locations and the possible measures to control the noise level for minimizing the impacts

LIST OF EXPERIMENTS

1. To study principle, components and working operation of Respirable Dust Sampler (RDS) for collection of respirable dust.
2. To study principle, components and working operation of Fine Dust Sampler for sampling.
3. Assessment of PM10 level in the ambient air.
4. Assessment of fine dust (PM2.5) concentration in the outdoor environment.
5. Understanding of principle, component and working of gaseous sampler for sampling of gaseous air pollutants in surrounding air.
6. Determination of gaseous air pollutants concentration in the ambient air
i. Oxides of Nitrogen (NOx)
ii. Oxides of Sulphur (SO_2)
iii. Ammonia (NH_3)
iv. Ozone (O_3)
7. Assessment of Ambient Air Quality and Air Quality Index (AQI) of the ambient air
8. Plot Wind Rose diagram to summarize meteorological condition.
9. Study of plume behavior in relation with wind velocity in your surrounding area.
10. Determination of SPM and gaseous pollutants concentration from stack emission of an industrial unit.
11. Determination of different noise indices (L10, L50, L90, Leq) at different locations (residential, industrial, commercial and silent zone) using Sound Level Meter.
12. Group Activity
13. Field Activity/ Visit and Report submission

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

SUGGESTED WEB SOURCES:

1. http://moef.gov.in/
2. https://cpcb.nic.in/
3. https:/ /www.icmr.gov.in/
4. https://bis.gov.in/

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Practical Mapping of COs with POs and PSOs for EVS – Lab IV (Air and Noise: Sampling and Analysis) (EVS 209)

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- I
SUBJECT NAME: BIOSTATISTICAL METHOD & DATA ANALYSIS & LAB-I
Course code: CC-A03
Course ID: 241/EVS/CC103
NO. OF CREDITS: 3

L	T	P
2	0	1

TI	:	15
TE	:	35
PI	:	05
PE	:	20
Total	:	75

NOTE: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
At the completion of this course, the learner will be able to:
CO1: Obtain knowledge of probability and distributions and become capable of mathematical expectations.
CO2: Acquire the skills of regression and correlation analysis, and development of statistical models and their use.
CO3: Become capable of design of experiments for R&D work and testing of the related hypotheses.
CO4: understand of the environmental systems and their analysis and become acquainted with the widely used ecological and environmental models.

UNIT-I:
Measurement of central tendency - mean (Geometric and Harmonic), median, mode, Measurement of dispersion moments, standard deviation, skewness and kurtosis, Correlation and linear regression of one independent variable, Basic laws and concepts of probability

UNIT-II:

Definition of random variable, density function, Basic concepts of binomial and normal distributions. Sampling measurement and distribution of attributes, moments, matrics and simultaneous linear equations, tests of hypothesis and significance.

UNIT-III:
Role of modelling in environmental sciences, Model classification deterministic models, stochastic models, steady state models, dynamic models, different stages involved in model building. Simple microbial growth kinetics monod equation, methods for formulation of dynamic balance equations mass balance procedures.

UNIT-IV:

Models of population growth and interactions, Lotka Volterra model, Leslies matrix model, Point source stream pollution, Box model, Gaussian plume model, Linear, simple and multiple regression models, validation and forecasting.

REFERENCE BOOKS:

1. S. C. Gupta and V. K. Kapoor, S. *Fundamental of Mathematical Statistics* –Chand &Sons Publisher.
2. *Statistical Methods* – S.P. Gupta S. Chand &Sons Publisher
3. *Fundamental of Statistics* – S.C. Gupta
4. C.S. Rao, *Environmental Pollution Control Engineering*, Wiley Eastern Ltd., New Age International Ltd., (1995).
5. M. L. Marx and Richard Larsen *An introduction to mathematical statistics and its applications*.
6. *Dynamics of Environmental Bioprocesses-Modelling and simulation-Snape and Dunn*.
7. *Environmental Modeling*– Jorgensen
8. Hogg, R.V. and Raise, A.T. (1978): *Introduction to mathematical statistics*, Macmillan Pub. Co. Inc.
9. Croxton, F.E. and Cowden, D.J. (1975): *Applied General Statistics*.
10. Hoel, P.G. (1997). *Introduction to Mathematical Statistics.*

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study.

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB I

Outcomes:

At the completion of this course, the learner will be able to:

CO1: understand the conceptual background behind statistical tests and assess appropriateness of for chosen analysis data sets.

CO2: graph and analyze data sets similar to those produced in the thesis work.

CO3: select applicable statistical tests to perform analyses, interpret results, and represent statistical findings accurately

CO4: evaluate study design, analysis, and interpretation by providing constructive feedback through the peer-review process

LIST OF EXPERIMENTS

1. Introduction to Statistical Computing in SPSS
2. Management of Research Data in SPSS Day

3. Graphical representation of data by Histogram, Frequency polygons, frequency curves and Ogives, stem & Leaf Plot, Box Plot.

4. Calculation of measures of location.

5. Calculation of measures of dispersion.

6. Calculation of moments, measures of skewness and measures of Kurtosis.

7. Fitting of curves by method of least squares.

8. Determination of regression lines and calculation of correlation coefficient - grouped and ungrouped data.

9. Calculation of correlation ratios and rank correlation coefficients.

10. Calculation of multiple and partial correlation coefficients for three variables

11. Calculation of measures of association in contingency tables.

12. Direct and Indirect Methods of Standardization.

13. Construction of Life Table and Abridged Life Table.

14. Calculation of measures of mortality and fertility.

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

REFERENCE BOOKS:

1. Margan G A: SPSS for Introductory Statistics; Uses and Interpretation.

2. Practical Work Book by Bristol Information Services: Introduction to SPSS for Windows.

3. Introductory Practical Biostatistics, B. N. Misra, M. K. Misra

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- I
SUBJECT NAME: ECOLOGICAL RESTORATION & LAB-I
Course code: DSE-01
Course ID: 241/EVS/DS101

NO. OF CREDITS: 3

L	T	P
2	0	1

TI	:	15
TE	:	35
PI	:	05
PE	:	20
Total	:	75

NOTE: 1. Nine questions will be set in all. All questions will carry equal marks.

2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV.

The candidates will be required to attempt question no.1and four more questions.

Outcomes: At the end of the course learner will be able to:

CO1. Understand the basic concept of ecological principles and their applications in ecosystem restoration

CO2. Understand the sources and effects of natural and anthropogenic disturbances on aquatic and terrestrial ecosystems

CO3. Learn about various strategies of restoration of degraded, salt affected and water logged areas.

CO4. Understand and apply the concept of biosaline agriculture, its scope and importance for resource conservation

CO5. Understand and apply the concept of Integrated watershed management and its restoration

CO6. Understand the mitigation strategies of invasive species with the help of case studies.

CO7. Understand the restoration of Coastal ecosystems, wetlands, riparian and floodplain ecosystems with case studies.

Note:-

NOTE: 1. Nine questions will be set in all. All questions will carry equal marks.

2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV.

The candidates will be required to attempt question no.1and four more questions.

Unit-I: INTRODUCTION

Basic principles and applications of Ecotechnology.

Restoration Ecology-Terms and definitions, Importance of ecological restoration: Strategies of Restoration-Natural recovery, active restoration, rehabilitation; Restoration plan and rehabilitation measures; Reference ecosystem.

Natural and anthropogenic disturbances: Characteristics and sources, effects on structure and functioning of terrestrial and aquatic ecosystems. Habitat fragmentation, Ecosystem Stability and regulation.

Global change and Human impact on ecological systems.

Unit-II: RESTORATION OF SOIL RESOURCES

Physical, Chemical, Biological tools of restoration. Ecological design principles.
Restoration of soil fertility of degraded lands: No-tillage, role of mycorrhizae, forestry Plantations, biofertilizers. Rehabilitation of salt affected soils and water-logged soils. Biosaline agriculture- Scope and importance and strategies.

Unit-III: RESTORATION OF LAND RESOURCES

Ecological restoration of forest and grassland ecosystems. Forest landscape restoration; Basic concepts and case studies. Reclamation of mining sites and disturbed lands. Integrated watershed management and restoration. Prevention and mitigation of invasive species.

Unit-IV: RESTORATION OF WATER RESOURCES

Ecological restoration of aquatic systems: River corridors, wetlands and lakes. Coastal restoration-mangroves and coral reefs. Rehabilitation of Tsunami affected areas- a general account. Treatment wetlands, Constructed wetlands and adaptive restoration of wetlands. Restoration of riparian and floodplain ecosystems.

Reference Books:

1. Botkin, D.B. and E.A. Keller (2004). Environment Science: Earth as a Living Planet, John Wiley & Sons Inc., New York.
2. Mitsch, W.J. and Jorgensen, S.E 2003. Ecological engineering and Ecosystem restoration. ical Perspective. John Wiley and Sons, New York.
3. Mitsch, W.J. and Jorgensen, S.E. (eds.) 1989. *Ecological Engineering: An Introduction to Ecotechnology*. John Wiley and Sons, New York.
4. Pace, M.L. and Groffman, P.M. (Eds.) (1998). Success, limitations and Frontiers in Ecosystem Science, Springer Verlag, New York.
5. Singh, J.S., Singh, S.P. and Gupta, S.R. (2015). *Ecology, Environment and Resource Conservation*, S. Chand Publishing, New Delhi.

Teaching-Learning Process

- **Lectures:** Supported by black board teaching, power point presentations, related videos and demonstrations
- **Assignments and exercises**
- **Test:** Knowledge of the students is tested through surprise tests, quiz and sessional tests.

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- II
SUBJECT NAME: ENVIRONMENTAL GEOSCIENCES & Lab III
Course code: CC-A04
Course ID: 241/EVS/CC204

NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:

At the completion of this course, the learner will be able to:

CO1: Understand the basics of the Earth's structure, composition and evolution of landforms

CO2: Analyze the effects of meteorological parameters on the dispersion of pollutants.

CO3: Understand and apply the basic concepts of meteorology, climatology and oceanography for solving relevant environmental issues.

CO4: Identify the issues related to climate change, understand reasons and recommend remedial measures

UNIT-I: EARTH PROCESSES

Earth Structure and Materials of the Earth; Minerals and Rocks; Weathering and Erosion. Plate tectonics; Volcanicity; Seismicity; Geological Time Scale.

UNIT-II: METEOROLOGY

Fundamentals of meteorology, Scales of meteorology, Parameters of meteorology- pressure, wind, temperature, humidity, radiation; Radiation laws, shortwave and long wave radiations, Albedo, Emissivity, Inversion; The boundary layer; Radiation balance of the Earth; Heating of Earth' surface and its atmosphere; Rotation of the Earth- Coriolis acceleration; Circulation of water and energy in atmosphere, El Nino, La Nina

UNIT-III: CLIMATOLOGY

Seasons and monsoons, Precipitation, Cloud classification and formation Local microclimate Weather and Climate in India, Climatic classification schemes, Climate change - Emissions and Global warming.

UNIT-IV: OCEANOGRAPHY

Sea water properties, Chemistry of seawater, Waves, Tides and Currents, Upwelling and El Nino, Marine Resources, Marine Pollution, Global Warming and Oceans - Greenhouse effect, Ocean warming, Sea level rise, Acidification, Carbon sequestration.

REFERENCE BOOKS:

1. Bell F. G., (1998). *Environmental Geology: Principles and Practice*. Blackwell Science Publisher, USA.
2. Critchfield H. J. (2009). *General Climatology*, PHI Learning, New Delhi.
3. Kale, V. S. and Gupta, A. (2001). *Introduction to Geomorphology*. Orient Longman, Bangalore.
4. Singh, S. (2011), *Physical Geography*, Prayag Pustak Bhavan, Allahabad.
5. Strahler, A.N. and Strahler (1996). *An Introduction to Physical Geography*. John Wiley & Sons, UK.
6. D.S. Lal (2011). *Climatology*, Sharda Pustak.
7. Frank Press, Raymond Siever, John Grotzinger, *Understanding Earth*. Editors Thomas H. Jordan, Tom Jordan W. H. Freeman & Co Ltd ISBN-10: 1464138745; ISBN-13: 978-1464138744
8. Frederick K. Lutgens Edward J. Tarbuck Pearson Education, *The Atmosphere An Introduction to Meteorology* Inc. ISBN-10 0-32-158733-2 ISBN-13 978-0-321-58733-6
9. Tom Garrison *Essentials of Oceanography* ISBN-13: 978-0-495-55531-5 ISBN-10: 0-495-55531-Brooks/Cole Cengage Learning 10 Davis Drive Belmont, CA 94002-3098 USA

SUGGESTED WEB SOURCES:

1. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study.

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB III

Outcomes: After completion of course, learners will be able to:

CO.1 to demonstrate the basic lab skills: identifying minerals and rocks;

CO.2 Inferring rock origin from examination of specimens; reading, drawing and interpreting contour maps and profiles;

CO.3 Using terrestrial coordinates.

List of practical:

1. Toposheet Analysis, Their Number, Scale and Index. Determination of physiographical features with the help of toposheet.
2. Preparation of Contour line map (choose one suitable sector of toposheet) and demarcation of higher and lower landmarks with direction.
3. Preparation of Drainage map and drainage density of a given watershed area.
4. Preparation of watershed map and analysis of slope of sub watershed area
5. Laboratory observations of different folds and faults
6. To draw the profile/section of different beds in the given Geological map
7. Drawing of strike line & determination of true dip & apparent dip
8. Laboratory Study and Observations of Physical Properties of Minerals.
9. Study of rock specimens and its physical properties (Igneous, Sedimentary and Metamorphic rock).
10. Study through GPS-Latitude, Longitude, Elevation etc
11. Study of Water table fluctuation through secondary data and Calculation of TARR value

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

Reference Books:

1. Textbook of Geology – G. B. Mahapatra, CBS.
2. Textbook of Geology – P. K. Mukherjee, World Press.
3. Practical Geology – Dr. Harish Kapasya, Himanshu Publication.

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- II
SUBJECT NAME: WATER POLLUTION & CONTROL TECHNOLOGIES & EVS Lab III
Course Code: CC-A05
Course ID: 241/EVS/CC205

NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
At completion of this course, the learner will be able to:
CO1: Acquire the knowledge of basic rationale of water quality management.
CO2: Characterize the typical inorganic and organic pollutants from a variety of sources entering into water bodies.
CO3: Design and develop water purification techniques for safe drinking water and wastewater treatment technologies for abatement of water pollution.
CO4: Apply the knowledge of various methods for water resource management.

UNIT-I: DRINKING WATER CHARACTERISTICS AND PURIFICATION TECHNIQUES
Water Sources – Availability and quality of Surface water and Groundwater, Water Requirements for Domestic Consumption (Population forecasting), Drinking water standards (physical, chemical & bacteriological), Water Treatment process – Principal, process design and applications (Aeration, flocculation, Sedimentation, Filtration, Disinfections (Chlorination, UV, Ozonation), water softening.

UNIT-II: WATER POLLUTION
Sources, types, Causes and consequences of water pollution, water pollutants (organic, inorganic, biological and radioactive pollutants), Marine pollution, Thermal pollution, Oil pollution, Classification of wastewater, Bioindicators.

Characteristics of water and wastewater, Sampling of water and wastewater, collection and storage, physical chemical and biological analysis of water and wastewater.

UNIT-III: WASTEWATER TREATMENT

Wastewater generation, objectives of waste water treatment, Primary, secondary, Tertiary treatment: sedimentation, coagulation and flocculation, filtration, disinfection, activated sludge process, trickling filters, and anaerobic (UASB) processes, Suspended, attached and hybrid reactors. Sludge treatment – Preliminary operation, Thickening, Conditioning, Dewatering, Filtration, Digestion and Drying of sludge, Sludge disposal. An introduction to common ETPs and STPs. wastewater treatment for small communities – Oxidation ditch, SBR, aerated lagoon.

UNIT-IV: WATER RESOURCE MANAGEMENT

Eutrophication, Recovery of eutrophicated lakes, rehabilitation of polluted rivers-Ganga Action Plan, Yamuna Action Plan and new Plans introduced by Govt. of India.

REFERENCE BOOKS:

1. *Wastewater Engineering: Treatment, disposal, Reuse* – Metcalf & Eddy Inc.4th ed. TMGHl, New Delhi, 2003.
2. *Environmental Engineering*- Peavy, HS, Donald RR & G. Tchobanoglous, MGH Int. Ed. New York, 1985.
3. Edzwald, James K. (ed.) *Water quality & treatment: A handbook on drinking water*
4. Ujang, Zaini (Ed.) *Municipal wastewater management in developing countries: Principles and Engineering*.
5. *Natural Resources conservation*-Oliver S Owen & Chiras
6. *Natural Resource Conservation*-Owen & Chiras
7. *Living in the Environment* –T.J.Miller

SUGGESTED WEB RESOURCES

1. https://cpcb.nic.in/
2. https://www.epa.gov/environmental-topics
3. https://www.unccd.int/issues/land-and-drought

MODE OF TRANSACTION:

Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study, e-learning, Experimentation, Tutorial, Problem solving, Self-learning

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB III (Water & Soil Analysis)

COURSE OUTCOME: At the completion of this course, the learner will be able to:

CO1: Illustrate the different physio-chemical analysis of water, wastewater and soil.
CO2: Apply the appropriate method of physico-chemical analysis to research and field applications.
CO3: Estimate the pollution levels in water, wastewater and soil
CO4: Apply the skill acquired in planning of various treatment technologies.

LIST OF EXPERIMENTS:

1. Study of Physical characteristics of water: Colour, Odour, Turbidity, Temperature.
2. Determine the water holding capacity and moisture content in soil sample.
3. Determination of ORP of the water/soil sample.
4. Determination of Salinity of the water/soil sample.
5. Determination of DO of the water sample.
6. Determination of Fluoride content in the water sample by Spectrophotometric method.
7. Estimation of Nitrate in water sample by Spectrophotometric method.
8. Estimation of Phosphate in water sample by Spectrophotometric method.
9. Determination of cations (Na, K, Ca and Mg) in a given water/soil sample by using a Flame photometer.
10. Determination of Cation Exchange Capacity of soil.
11. Determination of Total Kjehldahl Nitrogen (TKN) in soil samples.
12. Determination of Total Organic Carbon of a soil samples.
13. Determination of Heavy metals in soil samples.
14. Determine the Lime and gypsum requirements of soils.
15. Group Activity
16. Field Activity/ Visit and Report submission

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

REFERENCE BOOKS:

1. American Public Health Association (APHA) (2012). *Standard method for examination of water and wastewater*, 22nd edn. APHA, AWWA, WPCF, Washington.
2. Yadav, M. S. (2008). *Instrumental methods of chemical analysis*, Campus Books International. Delhi.
3. Quevauviller, P. (2006). *Analytical methods for drinking water: Advanced in sampling and analysis*, John Wiley Publisher.
4. Patnaik, P. (2010). *Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes*, London: CRC Press.
5. Nollet, L. M. L (2007). *Handbook of water analysis*, London: CRC Press.
6. Gupta, P. K. (2009). *Methods in environmental analysis water, soil and air*, Jodhpur: Agrobios.

SUGGESTED WEB SOURCES:

1. http://moef.gov.in/
2. https://cpcb.nic.in/
3. https://www.icmr.gov.in/
4. https://bis.gov.in/

MODE OF TRANSACTION:

Demonstration, Lecture, E-tutoring, Hands on training, discussion, assignments, Practical

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- II
SUBJECT NAME: Instrumental Techniques for Environmental Analysis & EVS – Lab IV (AIR AND NOISE: SAMPLING AND ANALYSIS) & EVS Lab III
Course Code: CC-A06
Course ID: 241/EVS/CC206
NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
At the completion of this course, the learner will be able to:
CO1: Understand the problem and identify suitable techniques to analyze the environmental samples.
CO2: Explain and use suitable sampling methods for collection of different samples to perform physical, chemical and biological characterization of environmental pollutants.
CO3: Appraise the principles, working and applications of the instrumental techniques used for analysis of physical, chemical and biological entities.
CO4: Differentiate between the various analytical methods and capable to design method required for quantitative and qualitative analysis of environmental components.

UNIT I: BASICS OF ANALYTICAL APPROACH
Analytical Approach: Defining of Problem and Designing of Analytical Method; Sampling: Types and Methods for Solid, Liquid and Gaseous Matrix; Sample Storage; Sample Preparation; Measurement and Assessing of Data; Method Validation and Documentation;
Wet Chemical Methods: Titrimetry; Gravimetry

UNIT-II: SPECTROMETRIC ANALYTICAL TECHNIQUES
UV- Visible spectrophotometer, Flame photometry, atomic absorption spectrophotometry; Plasma Emission Spectroscopy; X-Ray Spectroscopy (X-Ray Fluorescence, X-Ray Diffraction); Fourier-transform Infrared Spectroscopy (FTIR); Nephelometry and Turbidimetry

UNIT-III: CHROMATOGRAPHIC TECHNIQUES
Chromatographic Techniques (Paper Chromatography, Thin Layer Chromatography, Gas Liquid Chromatography, High Performance Liquid Chromatography, Ion-exchange Chromatography);

Electrophoresis

UNIT IV: MICROSCOPY TECHNIQUES

Optical Microscopy (Brightfield and Darkfield, Phase Contrast, Fluorescence, Confocal); Electron Microscopy (Scanning and Transmission Electron Microscopy)

REFERENCE BOOKS:

1. Hussain, C. M., & Kecili, R. (2019). *Modern Environmental Analysis Techniques for Pollutants*. Elsevier.
2. Khopkar, S.M. (2015). *Basic Concepts of Analytical Chemistry*. Wiley Eastern Ltd., New Delhi.
3. Mitra, S., & Kebbekus, B. B. (2018). *Environmental Chemical Analysis*. CRC Press.
4. Robinson, J. W., Frame, E. M. S., & Frame, G. M. (2014). *Undergraduate Instrumental Analysis*. CRC Press, New York
5. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). *Principles of Instrumental Analysis*. Cengage learning.
6. Willard, H.H., Merritt, L.L, Deen, J.A. and Settle, F.A. (2015). *Instrumental Methods of Analysis*. CBS Publishers and Distributers, New Dehi.
7. Patnaik, P. (2017). *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes.* CRC Press.

SUGGESTED WEB SOURCES:

1. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html
2. https://nptel.ac.in/courses/103/106/103106162/
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
4. https://swayam.gov.in/

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

EVS LAB IV (Air, noise sampling & analysis):

COURSE OUTCOME:

At the completion of this course, the learner will be able to:

CO1: Explain the different methods followed for sampling and analysis of analysis of air pollutants.

CO2: Appraise the quality of air and suggest management plans to control the air pollutants.

CO3: Determine the air pollutants level in stationary sources and explain the dispersion pattern with reference to the meteorological conditions.

CO4: Assess the noise level at different locations and the possible measures to control the noise level for minimizing the impacts

LIST OF EXPERIMENTS

1. To study principle, components and working operation of Respirable Dust Sampler (RDS) for collection of respirable dust.
2. To study principle, components and working operation of Fine Dust Sampler for sampling.
3. Assessment of PM_{10} level in the ambient air.
4. Assessment of fine dust ($PM_{2.5}$) concentration in the outdoor environment.
5. Understanding of principle, component and working of gaseous sampler for sampling of gaseous air pollutants in surrounding air.
6. Determination of gaseous air pollutants concentration in the ambient air
   i. Oxides of Nitrogen (NO_x)
   ii. Oxides of Sulphur (SO_2)
   iii. Ammonia (NH_3)
   iv. Ozone (O_3)
7. Assessment of Ambient Air Quality and Air Quality Index (AQI) of the ambient air
8. Plot Wind Rose diagram to summarize meteorological condition.
9. Study of plume behavior in relation with wind velocity in your surrounding area.
10. Determination of SPM and gaseous pollutants concentration from stack emission of an industrial unit.
11. Determination of different noise indices (L_{10}, L_{50}, L_{90}, L_{eq}) at different locations (residential, industrial, commercial and silent zone) using Sound Level Meter.
12. Group Activity
13. Field Activity/ Visit and Report submission

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

REFERENCE BOOKS:

1. Csuros, M. (2018*). Environmental sampling and analysis: lab manual*. Routledge.
2. Forbes, P. (2015). *Monitoring of air pollutants: sampling, sample preparation and analytical techniques.* Elsevier.
3. Gupta, P. K. (2018). *Methods in environmental analysis: water, soil and air*, 2nd Edition). Jodhpur, India: Agrobios Publication.
4. Hess-Kosa, K. (2018). *Indoor air quality: the latest sampling and analytical methods*. CRC press.
5. Lodge Jr, J. P. (2017). *Methods of air sampling and analysis.* 3rd Edition, CRC Press.
6. Maiello, M. L., & Hoover, M. D. (Eds.). (2019). *Radioactive air sampling methods,* 1st Edition, CRC press.
7. Patnaik, P. (2017). *Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes*, 3rd Edition, CRC Press.

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Practical

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- II
SUBJECT NAME: ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY & LAB IV
Course code: DSE-02
Course ID: 241/EVS/DS202
NO. OF CREDITS: 3

L	T	P
2	0	1

TI	:	15
TE	:	35
PI	:	05
PE	:	20
Total	:	75

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:

After completing this course, the students will be able to:
CO1: Understand various applications of microbiology and biotechnology and techniques for production of microbes and biodiversity conservation.
CO: Understand and apply basic techniques of biotechnology, their applications for detection of environmental contaminants and apply emerging environmental biotechnologies for biodegradation of compounds.
CO3: Apply the concepts for bioremediation of contaminated sites.
CO4: Apply the knowledge for the development of biodegradable and eco-friendly products and analyze the bioethical issues related to biosafety of Genetically Modified Crops.

UNIT-I: INTRODUCTION
Definition and importance of Environmental microbiology and biotechnology, Fermentative technologies, microbial enzymes, Batch and continuous culture of microbes for commercial use. Role of biotechnology in conservation of species: cryopreservation, tissue culture, gene banks

UNIT-II: ENVIRONMENTAL MONITORING AND ROLE OF MICROBES IN BIODEGRADATION
Biosensors in detection of environmental contaminants: BOD, methane, ammonia; Biomarkers of pollution and Bioindicators; Recalcitrance nature of xenobiotics and mechanisms of microbial metal resistance and detoxification. Biodegradation of halogenated hydrocarbons, Polycyclic aromatic hydrocarbons (PAHs) and Pesticides.

UNIT-III: BIOREMEDIATION OF POLLUTED ENVIRONMENTS
Environmental applications of bioremediation techniques, types of bioremediations, bioremediation of oil spills, limitations of bioremediation. Bioleaching. Phytoremediation:

Phytoremediation of xenobiotics and bioaccumulation of metals using plants. Phytoremediation-remediation using algae and recent approaches.

UNIT-IV: DEVELOPMENT OF BIODEGRADABLE AND ECO-FRIENDLY PRODUCTS

Biofuel and Biodiesel-plant derived fuels, bioethanol, biohydrogen; biofertilizers; biopesticides; bio-polymers. Bioethics in Environmental biotechnology: Genetically engineered microbes and GM Crops and Biosafety of GMM.

REFERENCE BOOKS:

1. Bhattacharyya, B. C., & Banerjee, R. (2007). *Environmental biotechnology*. USA: Oxford university press.
2. Bitton, G. (2013). *Wastewater microbiology*. John Wiley & Sons.
3. Lynch, J. M., & Wiseman, A. (2011). *Environmental biomonitoring: The biotechnology ecotoxicology interface*. Cambridge University Press, New York, NY(USA)
4. Rittmann, B. E., & McCarty, P. L. (2020). *Environmental biotechnology: principles and applications*. Tata McGraw-Hill Education.
5. Scragg, A. H. (2016). *Environmental biotechnology*. New York: OXFORD university press.
6. Thakur, I. S. (2011). *Environmental biotechnology: basic concepts and applications*. IK International.

SUGGESTED WEB RESOURCES

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://onlinecourses.nptel.ac.in/noc21_ce07/preview
3. https://onlinecourses.nptel.ac.in/noc21_bt22/preview
4. https://www.newcastle.edu.au/course/ERAR6010
5. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-89-environmental-microbiology-fall-2004/
6. https://www.coursera.org/courses?query=microbiology

MODE OF TRANSACTION:

Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point

LMS/ICT Tools: Digital Classrooms, DLMS, ZOOM, G Suite, MS Power-Point, Online Resource

Lab IV

At the completion of course learner will be able to:

CO.1 perform isolation, identification, maintenance and handling of microbial cultures in laboratory settings.
CO.2 handle microorganisms for isolation and amplification of DNA/RNA
CO.3 work and handle with techniques such as PCR, electrophoresis, etc.
CO.4 Plan and execute various microbiology research related practical independently or as a group.

List of Experiments:

1. Bacterial Growth Curve
2. Gram staining technique for identification of bacteria

PURE CULTURE TECHNIQUES:

3. Serial dilution Method
4. Pour plate Method
5. Spread plate Method
6. Streak plate Method

BIOCHEMICAL TESTS FOR BACTERIAL IDENTIFICATION:

7. Methyl Red Test
8. Voges –Proskauer Test
9. Catalase Test
10. Oxidase Test
11. Acid and Gas production Test

INSTRUMENT

1. Autoclave
2. Laminar Air Flow Chamber

BIOTECHNOLOGY:

1. Isolation of Chromosomal DNA from Microbes
2. Isolation of RNA from Spleen/Liver
3. Separation of DNA by Agarose Gel Electrophoresis
4. Polymerase Chain Reactions- Demonstration
5. MS Medium Preparation.
6. Synthetic Seed Preparation (Group Practical)

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

Reference books:

1. *A Photographic Atlas for the Microbiology Laboratory* by Michael J. Leboffe and Burton E. Pierce

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- II
SUBJECT NAME: ENVIRONMENTAL HEALTH AND SAFETY & LAB IV
Course code: DSE-2
Course ID: 241/EVS/DS202
NO. OF CREDITS: 3

L	T	P		
			TI	: 15
			TE	: 35
2	0	1	**PI**	: 05
			PE	: 20
			Total	: 75

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:

After completion of this course, the students will:

CO1: Learn about the environmental toxicants, their sources, origin and effects of various toxic materials and heavy metals that impact the environment adversely.

CO2: Correlate the common work-related diseases and train on methods used to assess the riskinvolved at occupational settings.

CO3: Manage handling and storage of hazardous substances at work place.

CO4: Analyze health and safety problems in the working as well as living environment and recommendations safety measures.

UNIT-I: INTRODUCTION

Basic Principle of Occupational Environment & Health and its implications.

Environmental Health: - Environmental health criteria. Effects of Industrial pollutants like mercury, lead, chromium, cadmium, arsenic and nitrate on human health. Water borne diseases; Prevention and protection of community health from water borne diseases. Indoor Air Quality of workplace and its effect on human health. Respiratory diseases associated with Industrial Environment. Effect of Noise on human health & it's preventive & control.

UNIT-II: OCCUPATION HAZARDS AND HAZARDOUS CHEMICAL

Occupation Hazards: - Occupational Environmental Hazards & its Types - Physical, chemical, biological, mechanical and psychosocial hazards, Occupational diseases, Ergonomics, Healthy workplace and its principles. Industrial hazard Analysis.

Hazardous chemicals: Classification of hazardous chemicals, Material Safety Data Sheet, transportation of hazardous chemicals, Hazchem code, Storage and handling of hazardous

substances, Compatibility of different chemicals, Emergency preparedness (on site & offsite), Safety mock drills, Safety audit, Concept of fire and explosion, Major accidents involving hazardous substances and consequence analysis. Case studies for Industrial Accidents.

UNIT-III: HEALTH AND SAFETY MEASURES

Health and Safety Measures: - Medical and engineering measures, Stress at work and its management, Personal protection equipment and their significance, Work permit system and its necessity, Risk Assessment with numerical, Risk management: organization and administration; techniques and practices. Disaster Management Plan of Industry.

Health Survey: Survey, analysis and recommendations regarding health and safety problems in the working and living environment. Biostatistics, epidemiology: Application of statistical methods to medical records in the study of health problems of human population in a given environment. First Aid & onsite medical facilities.

UNIT-IV: LEGISLATION MEASURES

Occupational Health and Safety Standards, OHSAS-18001 / ISO 45001, The factory Act, 1948 and its amendments, Manufacturing, storage and import of hazardous chemical rules, 1989 and its amendments. The Chemical Accidents (Emergency Planning, Preparedness & Response) Rules 1996 / 2000, The Public Liability Insurance Act 1991 & amendments, Gas Cylinder Rules, 1984 and amendments, The Static and Mobile Pressure Vessels (Unfired) Rules, 1981 and amendments etc.

REFERENCE BOOKS:

1. Nicholas, P Cheremisinoff, Madelyn L Graffia (1995) *Environmental and Health and Safety Management* 1st edition, William Andrew.
2. Barry S. Levy, David H. Wegman, Sherry L. Baron, Rosemary K. Sokas (2017) *Occupational and Environmental Health: Recognizing and Preventing Disease and Injury* 7th Edition OUP USA.
3. Jain, R. K., Rao S.S., (2000) *Industrial Safety, Health and Environment Management Systems* 4th Edition Khanna Publishers.
4. Robert H. Friis (2018) *Essentials of Environmental Health* 3rd Edition Jones and Bartlett Publishers, Inc.
5. Herman Koren, Michael S. Bisesi (2017) *Handbook of Environmental Health*, Volume I Biological, Chemical, and Physical Agents of Environmentally Related Disease CRC Press.
6. Prashar A. and Bansal P. (2010) *Industrial safety and Environment* S K Kataria and Sons.
7. Phillip Carson and Clive Mumford (1994) *Hazardous Chemicals Handbook* ScienceDirect.

8. Phillip R. B. (1995) *Environmental Hazards and human health* Lewis Publishers
9. Fulekar M.H. (2006) *Industrial Hygiene and Chemical Safety* I K International Publishing House
10. Major Hazard Control: A Practical Manual - An I.L.O. *Contribution to the International Programme on Chemical Safety* of U.N.E.P., I.L.O., W.H.O(1988) International Labour Office
11. Gupta A K., (2021) *Industrial Safety & Environment* Laxmi Publications

SUGGESTED WEBSITE:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://swayam.gov.in/
3. https://nptel.ac.in/courses/

MODE OF TRANSACTION:

Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point

LMS/ICT Tools: Digital Classrooms, DLMS, ZOOM, G-Suite, MS-Power-Point, Online Resource

LAB: Practicals will be devised depending on the facilities available.

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- III
SUBJECT NAME: ENVIRONMENTAL IMPACT ASSESSMENT AND AUDITING & EVS – Lab V (EIA and Auditing)
Course Code: CC-A07
Course ID: 241/EVS/CC307

NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
On completion of the course, the candidate will be able to:
CO1: Lay foundation on the concept and components of environmental impact assessment.
CO2: Develop the skill to write and design the draft of EIA report.
CO3: Understand and identify the key aspects of environmental audit
CO4: Understand how to write EIA report and risk analysis

UNIT - I: EIA INTRODUCTION
EIA origin, development, purpose and aims; core values and principles of Ecological Impact Assessment, EIA Methodology, EIA processes: Project screening, scoping, base-line data, impact identification; prediction, evaluation, valuation of environmental impacts, mitigation. Public participation, presentation, review and decision making, monitoring and auditing. Environmental Management Plan, Environmental components of EIA.

UNIT – II: EIA METHODOLOGY
Environmental Appraisal procedures in India, Impact identification methods. Environmental impacts of mining industry; nuclear power plant, textile industry; pulp and paper industry; petroleum refining; pesticide manufacturing industry; fertilizer industry.
Case studies of EIA – Hydroelectric dam and river valley projects; thermal power plants and petroleum exploration.

UNIT - III: ENVIRONMENTAL RISK ANALYSIS
Definition of risk, environmental risk analysis-risk assessment and risk management. Basic steps in risk assessment - Hazard identification. Dose-response assessment, Exposure assessment, Risk characterization, Risk assessment in EIA. Strategic Environmental Assessment (SEA)-principles and potential, improving the effectiveness of EIA.

UNIT -IV: EIA AUDITING

Aims and objectives of public involvement in EIA; Public involvement methods; approaches for EIA reviewing; Economic efficiency and valuation methods.

Types of environmental audits: Assessment and compliance audit, occupation health and safety; Energy audits. ISO 14001; Environmental Management systems in India;

Drivers for the development of audit programme. General audit process- preparation, excretions, performance valuation and execution. Environmental risk insurance; Environmental audit and EIA, Vocational prospects in the field of EIA, Auditing and EMS.

REFERENCES:

1. Canter, W. L. (1995) Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, New York
2. Kulkarni, V. and Ramachandra, T.V. Environmental Management. Capital Pub. Co., New Delhi. 2006.
3. Petts, J. Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers, UK 2005.
4. Glasson, J. Therivel, R. and Chadwick, A. Introduction to Environmental Impact Assessment. Routledge, London. 2006.
5. Fischer, T. B. (2007). Theory and Practice of Strategic Environmental Assessment, Earthscan, London.
6. Lawrence, D. P. (2003) Environmental Impact Assessment: practical solutions to recurrent problems, John Wiley & Sons, Hoboken NJ.
7. Morris, P. and Therivel, R. (1995) Methods of Environmental Impact Assessment, UCL Press, London.
8. Petts, J. (1999) (ed) Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science, Oxford.
9. Therivel, R. and Partidario, M. R. (1996) (eds) The Practice of Strategic Environmental Assessment, Earthscan, London.
10. Vanclay, F. and Bronstein, D. A. (1995) (eds) Environmental and Social Impact Assessment, Wiley & Sons, Chichester
11. Wood, C. (2003) Environmental Impact Assessment – A Comparative Review, Prentice Hall, London.

SUGGESTED WEB SOURCES:

1. https://swayam.gov.in/ &_https://nptel.ac.in/courses/
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
3. http://moef.gov.in/en/#

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study; **LMS/ICT TOOLS:** Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, OnlineResources

Lab V (EIA & AUDITING)

LIST OF EXPERIMENTS:

1. Study of recent EIA notification and guidelines
2. Baseline data collection and analysis
3. Study of impact identification methods – Checklists
4. Study of impact identification methods – Matrices
5. Study of impact identification methods – Networks
6. Study of cost-effect analysis of development project
7. Study of socio-economic impacts- Questionnaire method
8. Study of Environmental Risk Assessment- Data sheet method
9. Study of Environmental audit methods- Water Audit
10. Study of Environmental audit methods- Wastewater Audit
11. Study of Environmental audit methods- Energy audit- Electricity
12. Study of Environmental audit methods- Energy audit- Fossil fuels
13. Study of Environmental audit methods- Solid Waste audit

REFERENCE BOOKS:

Arts, J., & Morrison-Saunders, A. (Eds.). (2004). Assessing Impact: Handbook of EIA and SEA Follow-up (1st ed.). Routledge.

Carroll, B. & Turpin, T. (2009). Environmental Impact Assessment Handbook: Second Edition. Thomas Telford Ltd.

Barton, H., & Bruder, N. (1995). A Guide to Local Environmental Auditing (1st ed.).

Erickson, P. A. (1994). A Practical Guide to Environmental Impact Assessment

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- III
SUBJECT NAME: ENERGY AND ENVIRONMENT & LAB V
Course Code: CC-A08
Course ID: 241/EVS/CC308

NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
On completion of the course, the students will be able to:
CO1: Understand the basics of renewable and non-renewable energy resources and associated environmental issues.
CO2: Analyze, compare and appreciate the need for shifting towards alternative energy sources
CO3: Apply the understanding of waste to energy conservation technologies for designing sustainable waste management strategies.
CO4: Interpret sustainable technologies for waste minimization and energy conservation

UNIT-I: INTRODUCTION TO ENERGY RESOURCES
Energy scenario in the world and India; Potential and perspectives of energy resources in India; Classification of energy resources-conventional and non-conventional; Renewable and non-renewable; Environmental implications of energy resources, National energy plan; Energy conservation-principles and approach, green buildings, GRIHA ratings/norms, solar passive architecture, eco-housing, energy audit, national and international norms.

UNIT-II: CONVENTIONAL ENERGY
Fossil fuels (Coal, petroleum, LPG and natural gas) – origin, composition, physico-chemical characteristics, and energy content, sources properties and production process; Pollution from use of energy: combustion products of fossil fuels, Green Belt development and its importance.
Nuclear energy– fission and fusion; Nuclear enrichment, nuclear reactors, policies and regulations for nuclear waste disposal,

UNIT-III: NON-CONVENTIONAL ENERGY
Prospects of renewable non-conventional energy, Types - solar energy, wind energy, hydel, tidal and geothermal energy, OTEC: introduction, principle, generation. Solar collectors, applications

of solar energy: Solar water heating, solar heating and cooling of buildings, solar photovoltaics, solar distillation, solar cooking and solar ponds. Basic components of wind energy conversion system, types of windmills and applications of wind energy.

UNIT-IV: WASTE TO ENERGY AND ENERGY CONSERVATION

Bioenergy - Biomass as an energy source, characteristics of biomass, Energy plantations, Biomass conversion technologies. Types of biofuels- Biodiesel, bioethanol, biogas, biohydrogen - importance, production technologies and applications.

Waste to resource recovery and recycling for energy conversion technologies. Biogas generation: Feed stocks, factors affecting biogas generation, Biogas plants: Classification of biogas plants, advantages and disadvantages of biogas plants, community biogas plants. Microbial fuel cell – principle, types and challenges.

REFERENCE BOOKS:

1. Carla W. Montgomery, *Environmental Geology*, 5th ed., Mc Graw Hill Higher Education (2000).
2. G.D. Rai, *Non-Conventional Energy Sources*, 4th ed., Khanna Publication (1996).
3. S.A. Abbasi, *Renewable Energy Sources and Their Environmental Impact*, 1st ed. Ashok K. Ghosh, Prentice Hall of India (2001).
4. H.P. Garg and J.Prakash, *Solar Energy Fundamentals and Applications*, Tata Mc Graw Hill (1992).
5. S.P. Sukhantme, *Solar Energy: Principles of Thermal Collection and Storage*, 2nd ed., Tata Mc Graw Hill (1992).
6. S.Rao and B. Prulaker, *Energy Technology*, 1st ed., Khanna Publications (1996).
7. Lal, Banwari and Sarma, P.M., *Wealth from waste: Trends and technologies*, TERI (2011).
8. MNRE, *Griha manual volume - 3: Technical manual for trainers on building and system design optimization renewable energy application*, Ministry of new and renewable energy, 2011.
9. Pagliaro, Mario and Konstandopoulos, A.G. *Solar hydrogen: Fuel of the future*, Royal Society of Chemistry, 2012
10. Prasad, S and Dhanya M.S *Biofuels*, Narendra Publishing house, New Delhi, 2013
11. Rani Devi, Mohd. Kashif Kidwai, Pawan Kumar Rose and Alok Kumar Saran, *Energy water-waste nexus: For environmental management*, Narosa Publishing House, 2012
12. Rathore, N.S. *Renewable energy sources for sustainable development*
13. Sawhney, G.S. *Non -conventional energy resources*, PHI Learning Private Limited, 2012.
14. Sukhatme, S.P. Solar *Energy – Principles of Thermal Collection and Storage*. Tata McGraw Hill. 2000.
15. Tiwari, G.N. *Solar energy: Fundamentals, design, modeling and applications*, Narosa Publishers, 2002.

SUGGESTED WEB SOURCES:

1. https://swayam.gov.in/
2. https://nptel.ac.in/courses/
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
4. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html

5. http://moef.gov.in/
6. https://cpcb.nic.in/

MODE OF TRANSACTION:
Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study
LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

Lab V
Outcomes
CO.1 Measure solar radiations and test the performance of different solar thermal applications
CO.2 Characterize solar cells and analyze different parameters such as power flow, efficiency of different
CO.3 components such PV module, battery, inverter and PV system
CO.4 Characterize the properties of solid biofuels along with performance testing of cook stove
CO.5 Analyze the performance of wind energy converter and hybrid systems with DC and AC micro-grids.

LIST OF EXPERIEMENTS:

Measurement of total and diffuse solar radiation on a horizontal surface and comparison of computed values of total solar radiation on an inclined plane with experimental measured value, estimation of role of reflected component

Estimation of volatile matter and fixed carbon in biomass

Estimation of calorific value of solid fuels

Energy and environment performance testing of cook stove: Water Boiling Test (WBT) and Kitchen Performance Test (KTP)

Thermal testing of a box type solar cooker: Determination of first and second figure of merit To determine the top heat loss factor of a box type solar cooker

Cooling test on paraboloid concentrator solar cooker to determine its F'UL Heating test on paraboloid concentrator solar cooker to determine its F'ɳ0

Reference books:

1. Garg, H. P., and Kandpal, T. C. (1999). Laboratory manual on solar thermal experiments. Narosa Publishing House, New Delhi.
2. Doebelin, E.O. 2004. Measurement Systems Application and Design, 5th ed. McGraw-Hill, New York. (selfstudy)
3. D.P.Kothari and D.K.Sharma (2000), Energy Engineering: Theory and Practice. S. Chand Publisher, New Delhi.
4. http://cleancookstoves.org/technology-and-fuels/testing/protocols.html

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- III
SUBJECT NAME: Solid and Hazardous Waste Management
& EVS – Lab VI (Waste Management)
Course Code: CC-A09
Course ID: 241/EVS/CC309

NO. OF CREDITS: 4

L	T	P
3	0	1

TI	:	25
TE	:	50
PI	:	05
PE	:	20
Total	:	100

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
At completion of the course, the learner will be able to:
CO1: Understand various concepts related to solid waste management.
CO2: Apply steps in solid waste management - waste reduction at source, collection techniques, materials and resource recovery/recycling, transport, optimization of solid waste transport, treatment and disposal techniques.
CO3: Acquire the knowledge related to hazardous waste management.
CO4: Evaluate the solid waste management according to the legal framework.

UNIT-I: MUNICIPAL SOLID WASTE
Solid wastes: Sources, classification, characteristics of solid waste, Waste generation rates, Collection and storage of municipal solid wastes, transfer stations, waste processing - volume and size reduction, source reduction, recycling, waste minimization.

UNIT-II: WASTE TREATMENT AND DISPOSAL
Waste processing technologies, Incineration, Combustion, Stabilization, Solidification, chemical fixation, encapsulation, Composting, Vermicomposting, Energy from waste – Bio- gasification - Anaerobic digestion, pyrolysis, refuse derived fuels; Landfill bioreactors, Burning, open dumping problems, Landfill – site selection, Sanitary and secured – structure, design, construction, operation and closure. Landfill leachate and gas management, Landfill bioreactors.

UNIT-III: HAZARDOUS WASTE MANAGEMENT
Hazardous waste: Definition, sources, classification, collection, segregation, characterization, Treatment and disposal.

Radioactive wastes: Definition, sources, classification, collection, segregation, Treatment and disposal.
E waste: Definition, sources, classification, collection, segregation, Treatment and disposal.
Biomedical wastes: Definition, sources, classification, collection, segregation, Treatment and disposal.

UNIT-IV: WASTE MANAGEMENT LEGISLATION

Solid Waste (Management and Handling) Rules, 2000, 2016 and amendments, Biomedical Waste (Management and Handling) Rules, 2016; Plastic Waste Management Rules, 2016; E-Waste Management Rules, 2016; Bio-Medical Waste Management Rules, 2016; Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; Construction and Demolition Waste Management Rules, 2016. Schemes and programs of Government- Swachchh Bharat Abhiyaan.

REFERENCE BOOKS:

1. Solid Waste Management Manual CPCB, New Delhi.
2. *Ecotechnology for Pollution Control and Environmental Management* by Trivedy R.K. and Arvind Kumar.
3. Williams, Paul T. (2013) *Waste treatment and disposal*, John Wiley Publishers.
4. Johri, Rakesh (Ed.), (2009) *E-waste: Implications, regulations and management in India and Current global best practices*, TERI press.
5. Letcher, Trevor M. (Ed.) (2011) *Waste: A handbook for management*, Academic Press London.
6. Sahai, Sushma (2009) *Bio- medical waste management*, APH Publishing.
7. Rosenfeld, Paul E., (2011) *Risks of hazardous wastes*, Elsevier London.
8. R E Hester (ed.); Roy M Harrison (ed.) (2008) *Electronic waste management: design, analysis and application*, Cambridge Royal Society of Chemistry.
9. Rao, M.N. and Sultana, R. (2012). Solid and Hazardous Waste Management, BS Publications, Hyderabad.

SUGGESTED WEB SOURCES:

1. https://cpcb.nic.in/rules-2/
2. https://vikaspedia.in/energy/environment/waste-management/solid-waste-managementrules
3. https://swachhbharat.mygov.in/
4. http://www.indiaenvironmentportal.org.in/content/about-us/

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB VI Waste management

COURSE OUTCOME:

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

CO1: Understand the importance of source segregation of solid waste for reduction of waste quality
CO2: Determine the physical and chemical characteristics of solid waste
CO3: Understand and explain the municipal solid waste management system operated in their locality.
CO4: Compare, select and design sustainable practices to manage the solid waste.

LIST OF EXPERIMENTS

1. Identify the sources and determine the composition of solid waste in a locality.
2. Determination of physical characteristics of given solid waste samples.
    a) pH
    b) Conductivity
    c) Moisture content
    d) Particle size distribution
    e) Field capacity
3. Determine the chemical characteristics of a given solid waste sample.
    a) Energy Content through bomb calorimeter
    b) Potassium (K)
    c) Calcium (Ca)
    d) Magnesium (Mg)
    e) Ammonical nitrogen (NH_4^+ - N)
    f) Nitrate Nitrogen (NO_3^--N)
    g) Sulphate (SO_4^{2-}-S)
    h) Phosphate (P)
4. To determine the ash content and organic carbon content of given solid waste material.
5. Survey your locality and suggest suitable methods of handling, segregation and storage of solid waste.
6. Identify and discuss various suitable methods for disposal of solid waste in your locality.
7. Conduct composting/vermicomposting experiments for the management of organic content in the solid waste.
8. Explore your locality and identify and discuss solid waste collection, transportation, treatment and disposal methods.
9. Group Activity
10. Field Activity/ Visit and Report submission

Note: This list of experiments is indicative. Addition and deletion in the list of experiments may be made from time to time by the department depending on the availability of resources.

REFERENCE BOOKS:

1. Cherry, P. M. (2016). *Solid and Hazardous waste management,* New Delhi: BCS publishers and Distributors.
2. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: a global snapshot of solid waste management to 2050.* World Bank Publications.
3. Letcher, T. M., & Vallero, D. A. (Eds.). (2019). *Waste: A handbook for management.* Academic Press.

4. Patnaik, P. (2017). *Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes*, 3rd Edition, CRC Press.
5. Williams, P. T. (2013). *Waste treatment and disposal.* John Wiley & Sons.
6. Zhu, D., Asnani, P. U., Zurbrugg, C., Anapolsky, S., & Mani, S. K. (2007). *Improving municipal solid waste management in India: A sourcebook for policymakers and practitioners.* The World Bank.

SUGGESTED WEB SOURCES:

1. http://moef.gov.in/
2. https://cpcb.nic.in/
3. https://www.icmr.gov.in/
4. https://bis.gov.in/

MODE OF TRANSACTION:

Demonstration, Lecture, E-tutoring, Hands on training, discussion, assignments, Practical

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- III
SUBJECT NAME: SOIL SCIENCE AND ECO- AGRICULTURE & LAB VI
Course code: DSE-3
Course ID: 241/EVS/DS303
No. Of credits: 3

L	T	P
2	0	1

TI	:	15
TE	:	35
PI	:	05
PE	:	20
Total	:	75

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV.
The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:
On completion of the course, the students will be able to:
CO1: Understand various means of soil contamination, their possible effects and control.
CO2: To create the understating about sources and impact of soil pollutants
CO3: To understand and evaluate different soil management technology.
CO4: Skilled in development of eco-agriculture practices in villages**.**

UNIT-I: SOIL FORMATION AND ITS COMPONENTS
Definition, rocks, minerals, soil weathering processes, soil formation, soil forming factors, Soil profiles and horizons, composition of soil, Soil water and organics matter, soil biota and their function in soil, Soil nutrient cycling, Physico-chemical and biological properties of soil, Soil sampling and analysis methods. Types of Indian Soil.

UNIT-II: SOIL POLLUTION AND SOIL EROSION
Definition, sources- point and non-point, routes. Soil pollutants –Types, pesticides – classification, formulation, residual toxicity, synthetic fertilizers, heavy metals, microplastic in soil; Industrial waste effluents and interaction with soil components. Effects and impacts of soil pollution, biomagnification.
Salt affected soil and its case studies – Saline soils, Sodic soil, Usar, Kallar; Types of erosion – water and wind erosion, causes, soil loss equation.

UNIT-III: SOIL MANAGEMENT TECHNOLOGY
Methodologies for soil conservation, conservation of arable land, techniques of reclamation and restoration of soil, wasteland reclamation, soil salinity management, remedial measures for soil pollution, Biochar for soil remediation, Principles of weed management, Fly ash treatment, Zero Tillage technology

UNIT-IV: ECO-AGRICULTURE
Organic farming, Eco-farming Bioherbicides, Allelopathy, Vermicomposting, Biofertilizers.

Sustainable agriculture, Zero-Tilt, Terrestrial Phyto-stabilization -Aquatic Phytotechnology, Blasto filtration, Rhizoremediation, case studies in eco-agriculture practices.

REFERENCE BOOKS:

1. Botkin, Daniel B. and Keller, Edward A. *Environmental Science: Earth as a Living Planet*. 6th ed. John Wiley & Sons, USA. 2007.
2. Cutler, S.L, *Environment Risks and Hazard*. Prentice Hall of India, Delhi. 1999.
3. De, A.K., *Environmental Chemistry*. New Age International (P) Ltd. Publishers, New Delhi. 2000.
4. Biswas T.D. and Mukherjee S.K., *Textbook of Soil Sciences, Publisher*: McGraw-Hill Inc., US, 2nd edition, 1995.
5. Hillel, D., *Introduction to Soil Physics*, Academic Press, New York. 1982.
6. Kapoor, B.S. *Environmental Sanitation.* S. Chand & Sons, New Delhi. . 2000.
7. Raven, Peter H., Berg, Linda R. and Hassenzahl, David M. *Environment.* 6th ed. John Wiley & Sons., USA. 2008.
8. Sanai, V.S. *Fundamentals of Soil.* Kalayani Publishers, New Delhi. 1990.
9. Singh, H.P., Batish, D.R. and Kohli, R.K. *Handbook of Sustainable Weed Management*. Haworth Press, Inc., USA. 2006.
10. Singh, R.A. *Soil Physical Analysis*, Kalayani Publishers, New Delhi. 1997.

SUGGESTED WEB RESOURCES

1. https://onlinecourses.nptel.ac.in/noc20_ar05/preview
2. https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ar05/
3. https://nptel.ac.in/courses/126/105/126105016/
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
5. https://www.icar.org.in/

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB VI

Outcome

List of Experiments:

1. Collection and processing of soil for analysis
2. Study of soil profile and Its characteristics
3. Study of soil forming rocks
4. Study of soil forming minerals

5. Determination of densities of soil
6. Determination of moisture content from soil and plant
7. Determination of maximum water holding capacity (MWHC) of soil
8. Determination of hydraulic conductivity of soil
9. Determination of texture of soil
10. Measurement of soil temperature and calculation of soil heat flux
11. Determination of EC and pH of soil
12. Determination of cation exchange capacity of soil
13. Estimation of organic carbon content in soil

Reference books

1. Black, C.A. 1965 (Editor). Methods of Soil Analysis Part I. ASA, Inc. Publisher, Madison, Wisconsin, U.S.A.
2. Brechtel, H.M. 1976. Application of an Inexpensive Double ring Infiltrometer. FAO Conservation Guide No.2 pp 99-102.
3. Buol, S.W., F.D.Hole and R.J.Mcracken 1980. Soil Genesis and Classification. Second Edition. The Icwa State University Press, Ames, Iowa.
4. Foth, H.D., Study Guile. Fundamentals of Soil Science. Kendall/Hunt Publishing Company. 2460 Kerper Boulevard, Dubuque, Iowa 520U1.
5. Foth, H.D., L.V.Withee, H.S.Jacobs and S.J.Thien 1980. Laboratory Manual for Introductory Soil Science. Wm. C. Brown Company Publishing, Dubuque, Iowa. Jacobs, H.S., R.M.Reed, S.J.Thien, and L.V.Withee (Editors).1971. Soils Laboratory Exercise Source Book. ASA, Madison, Wisconsin, 53711.

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- II
SUBJECT NAME: ENVIRONMENTAL ISSUES AND LEGISLATION & LAB VI
Course code: DSE-3
Course ID: 241/EVS/DS303
NO. OF CREDITS: 3

L	T	P
2	0	1

TI	:	15
TE	:	35
PI	:	05
PE	:	20
Total	:	75

Note: 1. Nine questions will be set in all. All questions will carry equal marks.
2. Question no. 1 which will be short answer type, covering the entire syllabus will be compulsory. The remaining eight questions will be set unit wise selecting two questions from each unit I to IV. The candidates will be required to attempt question no.1and four more questions.

COURSE OUTCOMES:

After completing this course, the students will be able to:
CO1: Understand initiatives taken at national and international level to protect and conserve environment.
CO2: Know rules and regulations applicable to industries and other organizations with significant environmental aspects.
CO3: Apply the legislations to control pollution and for solving the local environmental problems.
CO4: Prepare the management plan to protect environment.

UNIT I: INTRODUCTION TO ENVIRONMENTAL LEGISLATIONS

Environment protection: Issues and Problems; International and National efforts for Environment Protection; General Principles in Environmental Law: Precautionary Principle; Polluter Pays Principle; Sustainable Development, Constitutional provisions of Constitution of India regarding Environment (Article 48A, 51A (g) and 253).

UNIT II: NATIONAL & GLOBAL ENVIRONMENTAL INITIATIVES

International Initiatives towards Environmental Protection: Stockholm Conference, Earth Summit, World Summit on Sustainable Development, Rio+20, Ramsar Convention, Vienna Convention, Montreal Protocol, Kyoto Protocol; Sustainable Development Goals; Ecomark Scheme

UNIT III: ENVIRONMENTAL LAWS & LEGISLATIONS

The Water (Preventions and Control of Pollution) Act, 1974; National Water Policy, 2002; Air (Prevention and Control of Pollution) Act, 1981; Environmental (Protection) Act, 1986; National Environmental Policy, 2006; Motor Vehicle Act, 1988 (Environmental Aspects only); Public Liability Insurance Act, 1991; Coastal Regulation Zone (CRZ) Notification, 1991; Noise Pollution (Regulation and Control) Rules, 2000

UNIT IV: LEGISLATION RELATED TO BIODIVERSITY

National Forest Policy, 1988; Wildlife Protection Act, 1972 and Amendments; Forest Conservation Act, 1980; Indian Forest Act, Revised 1982; Biological Diversity Act, 2002

REFERENCES BOOKS:

1. Divan S. and Rosencranz A. (2015). *Environmental Law and Policy in India***.** Oxford, New Delhi
2. Dwivedi, S. K., & Kashyap, P. (2013). Environmental Protection Law and Policy in India.
3. Ghosh, S. (Ed.). (2019). *Indian Environmental Law: Key Concepts and Principles*. Orient BlackSwan.
4. Leelakrishnan, P. (2016). *Environmental law in India*. LexisNexis.
5. Nath B., Hens, L., Compton, P. and Devuyst, D. (2018). *Environmental Management in Practice*, Vol I, Routledge, London and New York.
6. Singh, G. (2017). *Environmental law in India*. Mc Millan, New Delhi.
7. Upadhyay S. and Upadhyay V. (2017). *Hand Book on Environmental Law- Forest Laws, Wildlife Laws and the Environment*; Vols. I, II and III, Lexis Nexis- Butterworths-India, New Delhi.

SUGGESTED WEB SOURCES:

1. https://www.iucn.org/
2. https://indiankanoon.org/
3. www.cpcb.nic.in/
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
5. http://moef.gov.in/en/#

MODE OF TRANSACTION:

Lecture, Demonstration, PowerPoint presentation, E-tutoring, Discussion, Assignments, Case study

LMS/ICT TOOLS: Digital Classrooms, DLMS, ZOOM, G-Suite, MS Power-Point, Online Resources

LAB VI

Case studies

M.Sc. ENVIRONMENTAL SCIENCE – SEMESTER- IV
SUBJECT NAME: INDUSTRIAL TRAINING/RESEARCH PROJECT/ DISSERTATION
Course code: Dissertation
Course ID: 241/EVS/DISSERTATION401
NO. OF CREDITS: 20

L	T	P			
			PI	:	100
			PE	:	400
0	0	20	**Total**	:	50

COURSE OUTCOME:
The students will be able:
CO1: The students will get confidence to solve challenging problems related to the environment.
CO2: The decision-making skills will be enhanced due to practical exposure to environmental issues in field conditions.
CO3: The students will gain knowledge and develop the skill of report writing and research paper writing.
CO4: Demonstrate the ability to identify, analyze, and solve problems creatively.
CO5: Developed the ability to present and defend their project work to the expert

COURSE DESCRIPTION:
***Industrial Training/Research Project/ Dissertation*:** Every student will be required to undertake Industrial Training or a research project based on related areas of Environmental Sciences. The training/research project report will be submitted in the form of dissertation and will be presented for evaluation at the end of semester by an external expert. The internal and external assessment of training and project work will be carried out as following.

Internal Assessment:
- Synopsis
- One Mid-semester progress report/presentation

External Assessment:
- Final project report and viva-voce presentation.

Dissertation Report Submission Guidelines:

The dissertation report should be contained followings:

1. Dissertation report will contain a cover page, certificate signed by student and supervisor, table of contents, introduction, Objective, Literature review, methodology, results and discussions conclusion, and references.
   - The paper size to be used should be A-4 size.
   - The font size should be 12 with Times New Roman.
   - The text of the dissertation may be typed in 1.5 (one and a half) space.
   - The print out of the dissertation shall be done on both sides of the paper (instead of single

side printing)

- The total no. of written pages in dissertation report should be 40 to 60.

2. The candidate shall be required to submit three hard bound copies of dissertation along with a CD in the department as per the date announced.
3. Plagiarism should be below 20% (with filter of 5 words in a line from the same source) and students are required to produce letter of undertaking regarding plagiarism.
4. The candidate will defend her/his dissertation/project work through presentation before the External examiner at the end of semester and will be awarded marks.