Department of Environmental Sciences and Technology

Course Structure of M.Sc. (Environmental Sciences and Technology)

Academic Session 2021 – 22 onwards

School of Environment and Earth Science

Central University of Punjab

Graduate Attributes

The graduates passing the programme will have the knowledge, attitude and skill related attributes. The students will have comprehensive knowledge and understanding of various regional, national, & global environmental issues. The students will have the ability to apply the acquired knowledge in the rational manner for environmental management. The students will also have the ability to apply critical, creative and evidence-based thinking to solve the future challenges in the field of environment. The skill-linked-learning will inculcate research and entrepreneurial skills in the learners which make them to compete professionally at national/international level.

Course Structure

Semester I

Paper Code	Course Title	Course Type	Contact Hours			Credit
			L	T	P	C
EVS.512	Fundamentals of Environmental Science	F	3	0	0	3
EVS.513	Ecology and Biodiversity	F	3	0	0	3
EVS.514	Principles of Environmental Chemistry	CC	3	0	0	3
EVS.515	Atmospheric and Earth Science	CC	3	0	0	3
EVS.516	Environmental Pollution – I	CC	3	0	0	3
EVS.517	Ecology and Biodiversity (Practical)	S	0	0	2	1
EVS.518	Principles of Environmental Chemistry (Practical)	S	0	0	4	2
EVS.519	Environmental Pollution – I (Practical)	S	0	0	4	2
XXX	Interdisciplinary Course*	E	2	0	0	2
	Total		**17**	**0**	**10**	**22**
For students of other departments						
EVS.532	Waste Management in Our Daily life	IDC	2	0	0	2
EVS.533	Environmental Conservation	IDC	2	0	0	2
EVS.535	Environmental Geology	IDC	2	0	0	2
EVS.536	Health and Hygiene	IDC	2	0	0	2
EVS.537	Environmental Issues and Policies in India	IDC	2	0	0	2

F-foundation course; CC- core course; S- Skill course

L-Lecture, T-Tutorial, P-Practical; C-credits

*IDC course to be opted from other department Choice based credit system.

MOOC: MOOC may be taken upto 40% of the total credit (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match minimum 70% of our syllabus.

Semester II

Paper Code	Course Title	Course type	Contact Hours			Credit
			L	T	P	C
EVS.523	Energy and Environment	CC	3	0	0	3
EVS.529	Environmental Pollution -II	CC	3	0	0	3
EVS.530	Basics of Geospatial Technology	CC	3	0	0	3
EVS.538	Environmental Management and Auditing	CC	3	0	0	3
EVS.539	Environmental Pollution-II (Practical)	S	0	0	4	2
EVS.540	Basics of Geospatial Technology (Practical)	S	0	0	2	1
EVS.XXX	Elective I	E	3	0	0	3
EVS.XXX	Elective II	E	3	0	0	3
XXXX	Value Based Course	VB	2	0	0	2
	Total		**20**		**6**	**23**
List of Electives						
EVS.528	Natural resource management	E	3	0	0	3
EVS.556	Waste management	E	3	0	0	3
EVS.558	Natural hazards and disaster management	E	3	0	0	3
EVS.559	Microbial Technology for pollution abatement	E	3	0	0	3
EGS.521	Geochemistry and Isotope Geology	E	3	0	0	3
GEO.507	Climatology	E	3	0	0	3
List of value Based course						
EVS.503	Turning waste into product	VB	2	0	0	2

F-foundation course; CC- core course; S- Skill course

L-Lecture, T-Tutorial, P-Practical; C-credits

MOOC: MOOC may be taken up 40% of the total credit (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match minimum 70% syllabus.

Semester III

Paper Code	Course Title	Course type	Contact Hours			Credit
			L	T	P	C
EVS.552	Instrumental Methods of Analysis	CC	3	0	0	3
EVS.561	Research Methodology	CC	3	0	0	3
EVS.562	Statistical Methods and Data Analysis	CC	3	0	0	3
EVS.563	Redrafting Environmental Sciences (DEC)	F	2	0	0	2
EVS.564	Entrepreneurship	F	1	0	0	1
EVS.565	Instrumental Methods of Analysis (Practical)	S	0	0	4	2
EVS.XXX	Elective – III	E	3	0	0	3
EVS.527	Environmental Nanotechnology	E	3	0	0	3
EVS.557	Ecotoxicology and Occupational Health		3	0	0	3
EVS.567	Water and Wastewater Design and Engineering		3	0	0	3
EVS.600	Industrial and field visits and/or Internship and/or project anywhere and/or case study	S	0	0	8	4
	Total		**15**		**12**	**21**

F-foundation course; CC- core course; S- Skill course

L-Lecture, T-Tutorial, P-Practical; C-credits

MOOC: MOOC may be taken up 40% of the total credit (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match minimum 70%.

Semester IV

Paper Code	Course Title	Course type	Contact Hours			Credit
			L	T	P	C
EVS.600	Project/Dissertation/Training in academic institution or industry or NGO etc.	Skill	0	0	40	20

Semester I

Course Title: Fundamentals of Environmental Science
Paper Code: EVS.512

L	T	P	C
3	0	0	3

Total teaching hours: 45 h

Learning outcomes:

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

- Relate to the multidisciplinary nature of environmental science as discipline
- Interpret the relationship among different spheres of the environment
- Discuss the current global environmental issues
- Inspect various environmental laws and regulations

Unit 1: Introduction (12 Lectures)

Connecting to the issue of environment; ecology of environment; components of environment and their interactions. Environmental Science – definition, principles and scope, and its multidisciplinary approach. Environmental ethics and role of education in solving environmental issues. Environment moments as case studies.

Unit 2: Structure of the Environment (11 Lectures)

Atmosphere, Hydrosphere, Lithosphere and Biosphere - Definition, Structure and composition

Group Discussion, Student generated Questions, Pros and Cons method

Unit 3: Environmental Issues (11 Lectures)

Green House Effect - Greenhouse gases its sources, impacts, consequences and remedial measures; global warming. Global Climate change, World and Indian scenario, Acid Rain; Brown Haze, Photochemical smog, nuclear winter; Ozone depletion, Case Studies

Unit 4: Environmental disasters (11 Lectures)

Bhopal gas tragedy, Fukushima and Chernobyl disaster, Love Canal tragedy, Minamata Accident, and other disasters as Case studies

Suggested Readings:

1. Surana, D. M., Malviya, H. O (2020). *Environmental Studies*. SBPD Publishing House, Kindle Edition.
2. Grotzinger, J. P., Jordan, T.H. (2019). *Understanding Earth*, New York: Freeman & Company.
3. Cunningham, W. P., Cunningham, M. A. (2016). *Principles of Environmental Science, Inquiry and application*, McGraw Hills Education.
4. Cunningham, W. P, Cunningham, M. A. (2015). *Environmental Science – A global concern, 13th edition*, McGraw Hills Education Publisher.
5. Luthens, F., Tarbuck, E. (2015). *The atmosphere: An introduction to meteorology*, Pearson Publications.
6. Khoiyangbam, R. S., Navindu, G. (2015). *Introduction to Environmental Science*, New Delhi: TERI.
7. Chiras, D. D. (2014). *Environmental Science*, *10th ed.* Janes & Bartlett Publishers.
8. Dave, D. (2012). *Environmental Studies*, Publisher, CENGAGE learning.

9. Prasad, G. (2002). *Conservation of natural Resources*, New Delhi: Discovery Publishing.

Suggested Websites:

1. https://www.ipcc.ch
2. https://www.unep.org/
3. https://cpcb.nic.in/

Mode of Transaction: Lecture, power point, demonstration, case study, co-operative learning, group discussion, e-learning, google meet, zoom

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Ecology and Biodiversity
Paper Code: EVS.513

L	T	P	C
3	0	0	3

Total teaching hours: 45 h

Learning Outcomes
At the completion of the course, the student will be able to:

- Classify and characterize different types of ecosystems
- Distinguish between population dynamics and community dynamics
- Identify values and threats of biodiversity
- Demonstrate the strategies for biodiversity conservation

Unit 1: Basics of Ecology (11 Lectures)

Scope of ecology, origin and evolution of life, speciation, geological scale.

Biotic and abiotic factors, ecosystem, concept of ecotone, edge effect, habitats and niche.

Biomes- classification and characteristics, Biogeography – classification, Group Discussion, student presentation

Unit 2: Ecosystem Dynamics (10 Lectures)

Ecosystem Structure and functions, food chains and food webs, energy flows in different ecosystems, energy flow models, Types and characteristics of ecosystem- terrestrial (forest, desert, grassland) and aquatic (pond, marine), wetlands, estuaries, forest types in India. Biogeochemical cycles, Case Studies, Visit to local pond ecosystem

Unit 3: Population and Community Ecology (12 Lectures)

Population ecology: characteristics, types of interactions; population growth and regulation, 'r' and 'k' species, metapopulation, demes and dispersal, niche- types, keystone species.

Community ecology: types and interaction, ecological succession – types and mechanism, Landscape ecology, Theory of Island Biogeography, biological invasion, Pros and Cons method, Case Studies

Unit 4: Biodiversity and its conservation (12 Lectures)

Definition, types of biodiversity, values of biodiversity, threats to biodiversity. Hot spots of biodiversity, Biodiversity hotspots of India.

Causes of species extinction, IUCN Categories of threatened species, Red data book, Endangered and Threatened flora and fauna of India.

Strategies for Biodiversity conservation- in situ, ex situ; national and international initiatives for biodiversity conservation, One minute presentation, Visit to Zoo, Herbal garden

Suggested Readings:

1. William, D. B., Sally, D. H. (2020). *Ecology*, Fifth Edition, Oxford University Press, United Kingdom.
2. Fath, B. (2019). *Encylopedia of Ecology*, Vol 1-5, Elsevier Publishers, Netherlands.
3. Eugene P. Odum and Gary W. Barrett. (2018). *Fundamentals of Ecology*, 5th Edition. Cengage Learning, India Pvt. Ltd., New Delhi.
4. Sharma, P. D. (2018). *Ecology and Environment*, 13th Edition, Rastogi Publications, New Delhi
5. Lomolino, M. V., Riddle, B. R., Whittaker, R. J. and Brown, J. H. (2016). *Biogeography* (5th Ed), Sinauer Associates, United States.
6. Begon, M., Howrath, R. B., Townsend, C. R. (2014). *Essentials of Ecology*, 4th Edition. John Wiley & Sons, Inc., United States
7. Rockwood, L. L. (2015). *Introduction to Population Ecology*, Second Edition. John Wiley & Sons, Inc. and Blackwell., United States.
8. William, J. M., James, G. G. (2015). *Wetland*, Wiley-Interscience, New Jersey.
9. Richard B. Primack. (2014). *Essentials of Conservation Biology*, Sixth Edition. Sinauer Associates, Inc., United States.
10. Smith, T. M., Smith, R. L. (2014). *Elements of Ecology*, (9th Ed), Pearson. London.
11. Vandermeer, J. H., Riddle, B. R., Brown, J. H. (2013). *Population ecology: First principle* (2nd Ed), Princeton University Press, United States.
12. Day, J. W., Kemp, W. M., Alejandro, Y., Byron, C. C. (2012). *Estuarine Ecology* (2nd Ed), Wiley-Blackwell Publishers, United States.
13. Pandey, B. N., Jyoti, M. K. (2012). *Ecology and Environment*, APH Publishing Co-operation, New Delhi.
14. Peter J. M. (2011). *Community Ecology, Second Edition*. John Wiley & Sons, Inc. and Blackwell., United States.
15. Pahwa, S. (2011). *Forest & wildlife laws*, 1st edition, Global India Publications, Delhi.
16. Joshi, P. C., Joshi, N. (2009). *Biodiversity and conservation*, APH Publishing Co-operation, New Delhi.
17. Rana, S. V. S. (2009). *Essentials of Ecology and Environmental Science* (5th Ed), PHI Learning Pvt. Ltd., New Delhi
18. Kohli, R. K., Jose, S., Singh, H. P., Batish, D. R. (2008). *Invasive Plants and Forest Ecosystems*, CRC Press / Taylor and Francis, United Kingdom.

Suggested Websites:

1. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html
2. https://www.iucn.org/
3. https://www.cbd.int/

Mode of Transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point, google meet, zoom

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Principles of Environmental Chemistry
Paper Code: EVS.514

L	T	P	C
3	0	0	3

Total teaching hours: 45 h

Learning Outcomes

Student will be able to:

- Get basic concepts and a thorough knowledge of the environment and its chemistry
- Apply principles of green chemistry to solve environmental pollution
- Understand the chemical reaction and processes that govern the behavior of air, water, soil;
- Recognize types of toxic chemicals in environment and analysis

Unit 1: Basics of Chemistry (11 Lectures)

Fundamental of environmental chemistry: Mole Concept, Periodic table, Solution chemistry, Oxidation-reduction reaction.

Green chemistry: New trends in green chemistry, Basic principles, Atom economy concept and its environmental importance, Green reagents, Green solvents; Student generated Questions, Group tasks-assignments.

Unit 2: Air & Water Chemistry (12 Lectures)

Atmospheric chemistry: Composition of air, Chemical speciation, particles, ion and radicals, Formation of particulate matter, Photochemical reactions in the atmosphere,

Aquatic chemistry: Structure and properties of water, Basic water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD, alkalinity, carbonates, redox potential, major cations and anions, and heavy metals, Chemical composition of natural water types; Group Discussion, Think-pair-share method, Interactive demonstration

Unit 3: Soil Geochemistry (11 Lectures)

Chemistry of soil: Physio-chemical composition of soil, Inorganic and organic components of soil, micro and micro nutrients in soil, significance of C:N ratio, Cation exchange capacity (CEC), Sodicity, Reactions in soil solution. Concept of major, trace and rare earth elements (REEs) in soil, Origin of chemical elements in soils and their behavior, Soil pedogenic processes; Group Discussion, Case Studies, One minute presentation, Think-pair-share method

Unit 4: Quantitative analysis (11 Lectures)

Acid-base, complexometric, precipitation and redox titrimetry. Gravimetric analysis – total solids, suspended solids and volatile solids; Student generated Questions, Group tasks-assignments, Think-pair-share method, Interactive demonstration.

Suggested readings:

1. Pani, B. (2020). *Textbook of Environmental Chemistry,* 2nd Edition, New Delhi: International Ptv. ltd.
2. Kaur, H. (2018). *Environmental Chemistry,* Pragati Prakashan, Meerut.
3. Ahluwalia, V. K. (2017). *Advance Environmental Chemistry*. Teri Press Publisher.
4. Manahan, S. E. (2017). *Water chemistry: green science and technology of nature's most renewable resource,* USA: CRC Press.
5. Manahan, S. E. (2017). *Environmental Chemistry, 10th Edition*. USA: CRC Press.
6. Lancaster, M. (2016). *Green Chemistry: An Introductory Text,* UK: RSC Publishing
7. Weiner E. R. (2013). Application of Environmental Aquatic Chemistry: A practical guide. CRC Press Taylor & Francis Group.
8. Girard J. (2013). *Principles of Environmental Chemistry, 2nd Edition*. USA: James & Barlett Publishers.
9. Baird, C., Cann, M. (2012). *Environmental Chemistry,* USA: W.H. Freeman.
10. Subramanian, V. (2011). *A Textbook of Environmental Chemistry*, New Delhi: I.K International Publishing House.
11. Ahluwalia, V. K., Malhotra, S. (2009). *Environmental Science*, Ane Books Pvt. Ltd
12. Hillel, D. (2008). *Soil in the Environment: Crucible of Terrestrial Life, 1st edition.* USA: Academic Press.
13. Clark J. H. and Macquarrie, D. J. (2008). *Handbook of Green Chemistry and Technology*, UK: Wiley-Blackwell.
14. Harrison R. M. (2007). *Principles of Environmental Chemistry,* UK: RSC Publishing.
15. Connell D.W, (2005). Basic Concept of Environmental Chemistry. Publisher: CRC Press.

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://www.epa.gov/environmental-topics
3. https://chem.libretexts.org/Bookshelves/Environmental_Chemistry

Mode of Transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point, google meet, zoom

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Atmospheric and Earth Science
Paper Code: EVS.515

L	T	P	C
3	0	0	3

Total teaching hours: 45 h

Learning Outcomes:
At the completion of the course, the learner will be able to:
- Relate various earth processes
- Assess the meteorological parameters
- Explain the climate system of the earth
- Inspect the ocean circulation mechanism

Unit 1: Earth processes (11 Lectures)

Structure and Composition of the Earth; Plate tectonics; Mountain Building; Mass Movements; Vulcanicity; Seismicity; Formation of lakes, rivers and streams; Wind; Glacial processes; Group Discussion, Case Studies, One minute presentation

Unit 2: Meteorology (11 Lectures)

Composition of Atmosphere; Scales of meteorology, Parameters of meteorology- pressure, temperature, humidity, wind; Rotation of earth- Coriolis acceleration, angular momentum; Radiation; Radiation Budget of Earth; Cloud Morphology and Microphysics; Atmospheric stability and Thermodynamics; Group Discussion, Student generated Questions, Group tasks-assignments,

Unit 3: Climatology (12 Lectures)

The boundary layer; Local microclimate; Atmospheric movements; General meridional circulations: Hadley cells, Ferrel and Polar cells; Circulation of water and energy in atmosphere; Weather and Climate in India; Seasons and monsoons; Climatic classification schemes; Climate change adaptations and mitigation measures, Case Studies, One minute presentation

Unit 4: Oceanography (11 Lectures)

Sea water properties; Chemistry of seawater; Wind driven circulations in upper oceans; Waves, Tides and Currents; Upwelling and El Nino; Deep Ocean Circulations; Marine Resources and Diversity; Ocean warming, Sea level rise, Ocean acidification, role in Carbon sequestration; Group Discussion, Student generated Questions, Group tasks-assignments, Case Studies

Suggested readings:

1. Grotzinger, J. P., Jordan, T. H. (2019). *Understanding Earth*, New York: Freeman & Company.
2. Kusky, T. (2017). *The encyclopedia of Earth Science*, Viva book private limited.
3. Singh, S. (2017). *Physical Geography*, Allahabad: Prayag Pustak Bhavan.
4. Merritts, D., Menking, K., Wet, A. (2014). Kirsten, *Environmental Geology: An Earth Systems Science Approach*, New York: W. H. Freeman & company.
5. Siddhartha, K. (2014). *Oceanography: A Brief Introduction*, New Delhi: Kisalaya Publications Pvt.

Limited.
6. Trujillo, A. P., Thurman, H. V. (2014). *Essentials of Oceanography*, New York: Pearson education inc.
7. Roy, R. (2013). *Introduction to General Climatology*, New Delhi: Anmol publication private limited.
8. Strahler, A.N. (2013). *An Introduction to Physical Geography*, UK: John Wiley & Sons.
9. Kale, V. S., Gupta, A. (2012). *Introduction to Geomorphology*, Bangalore: Orient Longman.
10. D. S. Lal. (2011). *Climatology*, Sharda Pustak.
11. Veena. (2009). *Understanding earth science*, Delhi: Discovery
12. Critchfield, H. J. (2008). *General Climatology*, Pearson Education India.
13. Bell, F. G. (2007). *Basic environmental and engineering geology*, London: CRC Press.
14. Frank, P., Raymond, S. (2003). *Understanding Earth*. W. H. Freeman & Co Ltd.
15. Bell, F. G. (1998). *Environmental Geology: Principles and Practice*, USA: Blackwell Science Publisher.

Suggested Websites:

1. https://mausam.imd.gov.in/
2. https://public.wmo.int/en
3. NASA Earth Observatory: https://earthobservatory.nasa.gov/?eocn=topnav&eoci=logo

Mode of Transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point, e-learning, E-PG Pathshala, Google meet, Google forms, Zoom, Microsoft Teams

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Environmental Pollution-I

Paper Code: EVS.516

L	T	P	C
3	0	0	3

Total teaching hours: 45 h

Learning Outcomes

After completing this course, student will be able to:

- Characterize the typical inorganic and organic pollutants from a variety of sources entering into water and soil bodies
- Develop water purification techniques for safe drinking water and wastewater treatment technologies for abatement of water pollution
- Explain processes in weathering and soil formation
- Understanding methods for conservation and reclamation of soil

Unit 1: Water Pollution and Purification Techniques (12 Lectures)

Water pollution*:* Sources, types, Causes and consequences of water pollution; water pollutants (organic, inorganic, biological and radioactive pollutants); Marine pollution; Eutrophication; Group discussion.

Water purification for drinking process – Principal, process design and applications - Aeration, flocculation, Sedimentation, Filtration, Disinfections (Chlorination, UV, Ozonization), water softening Drinking water standards (physical, chemical & bacteriological); Field sampling, Visit to University Water Centre and Desalination plant.

Unit 2: Wastewater Treatment (11 Lectures)

Wastewater treatment: Wastewater generation; Classification, sampling and characterization of wastewater; Sewage treatment – Primary, secondary and tertiary treatment – process design and application; Principle, role and design of biological unit process in wastewater treatment - Aerobic (activated sludge process) and anaerobic (UASB) processes; activated sludge process modifications; Group tasks-assignments, Case Studies, Visit to Sewage treatment Plant

Unit 3: Soil Formation and Erosion (11 Lectures)

Soil formation: Soil weathering, soil forming processes and factors, composition of soil; soil profiles, physico-chemical and biological properties of soil, soil biota and their role in nutrient cycling, Soil types in India

Soil erosion: Types of soil erosion – water and wind erosion, and causes, Land degradation – causes and impacts, desertification and its control; Salt affected soil – Saline soils, Sodic soil; Group tasks-assignments, Case Studies, One minute presentation

Unit 4: Soil pollution and Management (11 Lectures)

Soil pollution: Sources of soil pollution – point vs. non-point source; type of soil pollutants (organic, inorganic (including heavy metals), synthetic pollutants and biological agents); causes of soil pollution – industrial wastes, urban wastes, agricultural practices, mining.

Soil management: Consequences and control measures of soil pollution, methods for soil conservation, wasteland reclamation, National Mission for Sustainable Agriculture; Group tasks-assignments, Case Studies, Pros and Cons method.

Suggested readings

1. Peirce, J., Vesilind, P. A., Weiner, R. (2020). *Environmental Pollution and Control* (4th Edition). Elsevier Publisher
2. Khopkar, S. M. (2020). *Environmental Pollution Analysis*. New Age International Pvt. Ltd.; 2nd edition.
3. Blum, W. E. H., Schad, P., Nortcliff, S. (2018). *Essentials of Soil Science: Soil formation, functions, use and classification* (World Reference Base, WRB), Borntraeger Gebrueder Publisher.
4. Metcalf & Eddy. (2017). *Wastewater Engineering: Treatment, Disposal, Reuse* (4th Ed.). New Delhi: TMGHl.
5. Peavy, H. S., Donald, R. R., Tchobanoglous, G. (2017). *Environmental Engineering*, New York: McGraw-Hill Education.
6. Dorian, G. (2017). *Elements of soil conservation*. Koros Press Ltd.
7. Singh, R. (2015). *Membrane technology and engineering for water purification: application, system design, and operation*, Elsevier Publisher.
8. Irena, S. (2015). *Heavy metal contamination of soil: monitoring and remediation*, New York: Springer.
9. Soggard, E. G. (2014). *Chemistry of advanced environmental purification processes of water: Fundamental and application*, Elsevier Publisher.
10. Alfred R. Conklin Jr. (2014). Introduction to soil chemistry- Analysis and Instrumentation. John Wiley & Sons Inc.
11. Agrawal, S. K. (2013). *Water Pollution,* APH Publisher.
12. Singh, B. S., Kumar, R., Singh, M. R. (2012). *Water pollution and Environment,* Enkay Publishing house.
13. Rathore, H. S., Nollet, L. M. L. (2012). *Pesticides- Evaluation of Environmental Pollution*. CRC Press.
14. Havlin, J. L., Tisdale, S. L. (2011). *Soil fertility and fertilizers: An introduction to nutrient management*, New Delhi: PHI learning.
15. Edzwald, J. K. (2011). *Water Quality & Treatment: A Handbook on Drinking Water,* McGraw-Hill Education.
16. Stuart, A. (2010). *Soil Pollution,* Apple academics, Oakville.
17. Palmer, E. (2010). *Water pollution,* Apple Academic Press, Inc.
18. Mishra, S. K. (2009). *Assessment of Water Pollution,* APH Publishing corp.
19. Thomas, S. V. (2008). *Water Pollution issues and development,* Nova science publishers.
20. Humberto, B., Rattan, L. (2008). *Principles of Soil Conservation and Management*. Springer Netherlands
21. Mishra, S. G., Vani, D. (2009). *Soil Pollution*, APH Publishing group.
22. Mirsal, I. A. (2008). *Soil pollution: origin, monitoring & remediation,* Springer, Berlin.
23. Mishra, P.C. (2008). *Soil Pollution and Soil Organisms*. APH Publishing Corporation
24. Raven, P. H., Berg, L. R., Hassenzahl, D. M. (2008), *Environment.* 6th ed. John Wiley & Sons., USA.
25. Blanco, H., Rattan, L. (2008). *Principles of soil conservation and management.* USA: Springer
26. Botkin, D. B., Keller, E. A. (2007). *Environmental Science: Earth as a Living Planet,* 6th ed. USA: John Wiley & Sons.
27. Ujang, Z. (2006). *Municipal wastewater management in developing countries: Principles and Engineering,* Iwa Publishing.
28. De, A. K. (2000). *Environmental Chemistry*, New Delhi: New Age International (P) Ltd. Publishers.

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

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Ecology and Biodiversity (Practical)
Paper Code: EVS.517

L	T	P	C
0	0	2	1

Total teaching hours: 30 h

Learning Outcomes:
Student will be able to:

- Apply techniques for qualitative and quantitative sampling of plant diversity
- Apply biochemical methods in ecological research of plant populations.
- Design scientific methods/experiments to study various ecological parameters and biodiversity in laboratory/field conditions

Experiments:

1. Familiarization with various biotic and abiotic components of the pond and forest ecosystem.
2. Determination of minimum quadrat size for studying vegetation in a grassland.
3. Estimation of density, frequency and abundance of plant species in grassland using quadrat method.
4. Evaluation of Importance value index (IVI) of species.
5. Estimation of index of diversity, richness, evenness and dominance of species
6. Determination of turbidity using a Secchi disk

Suggested Readings

1. Misra, R., Puri, G. S. (2018). *Indian Manual of Plant Ecology*. Scientific Publishers, India
2. Stephen, R. G. (2014). *Field and Laboratory investigations in agroecology*, Third edition, CRC Press, United States.
3. Darrell, V. (2010). *Ecology Laboratory Manual,* 1st Edition. McGraw-Hill Education, United States,
4. Magurran, A. E. (2003) *Measuring Biological Diversity*. Wiley-Blackwell, United States.

Mode of Transaction: Demonstration, Lecture, E-tutoring, Hands on training, discussion, assignments, Practical

Evaluation criteria: Continuous Assessment **(10 Marks):** Based on attendance in practical class, practical record, involvement in practical, etc.

End Semester Exam: Subjective Type Test (**40 Marks)** (30 Marks practical performance and 10 Marks viva)
Total Marks: 50

Course Title: Principles of Environmental Chemistry (Practical)
Paper Code: EVS.518

L	T	P	C
0	0	4	2

Total teaching hours: 60 h

Learning Outcomes
Student will be able to:

- Learn techniques for qualitative and quantitative analysis for water, wastewater and soil
- Design scientific methods/experiments to study various pollutants in laboratory/field conditions

Experiments

1. Lab safety procedures and protocols
2. Preparation of solutions of different molarity and normality
3. Introduction to laboratory glassware and instruments
4. Acid base titrations
5. Argentometry titration (determination of chloride ions in water)
6. Complexometric titration for determination of hardness (Total, Ca, permanent and temporary)
7. Turbidometry analysis (determination of sulfate)
8. Determination of alkalinity
9. Estimation of salts by gravimetry

Suggested Readings

1. Gopalan, R. (2020). *A laboratory manual for environmental chemistry*, Dreamtech Press, Wiley India Pvt. Ltd, Noida.
2. American Public Health Association (APHA). (2012). *Standard method for examination of water and wastewater,* 22nd Ed. APHA, AWWA, WPCF, Washington.
3. Patnaik, P. (2010). *Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes,* London: CRC Press.
4. Gupta, P. K. (2009). *Methods in environmental analysis water, soil and air*, Jodhpur: Agrobios.
5. Yadav, M. S. (2008). *Instrumental methods of chemical analysis*, Campus Books International. Delhi.
6. Nollet, L. M. L (2007). *Handbook of water analysis,* London: CRC Press.
7. Quevauviller, P. (2006). *Analytical methods for drinking water: Advanced in sampling and analysis*, John Wiley Publisher.
8. Dunnivant F M (2004). E*nvironmental laboratory Exercises for Instrumental Analysis and Environmental Chemistry*. Wiley Publisher.

Mode of Transaction: Lecture, demonstration, experiment, E-tutoring, discussion, assignments, case study, power point.

Evaluation criteria: Continuous Assessment: **10 Marks**

End Semester Exam: Subjective Type Test (**40 Marks)** (30 Marks practical performance and 10 Marks viva)

Total Marks: 50

Course Title: Environmental Pollution – 1 (Practical)
Paper Code: EVS.519

L	T	P	C
0	0	4	2

Total teaching hours: 60 h

Learning Outcomes

- Illustrate the different physio-chemical analysis of water, wastewater and soil
- Apply the appropriate method of physico-chemical analysis to research and field applications
- Estimate the pollution levels in water, wastewater and soil

Experiments

1. Determination of pH of water/soil sample.
2. Determination of total suspended solids in water
3. Determination of conductivity/TDS/ salinity of the water sample.
4. Determination of dissolved oxygen in water sample.
5. Determination of COD and Total Organic Content in waste water
6. Determination of BOD in waste water
7. To study the texture of given soil sample.
8. Determination of Total Kjehldahl Nitrogen (TKN) and ammonical nitrogen etc. in water and soil samples.
9. To study MPN in waste water.

Suggested Readings:

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.

Mode of Transaction: Lecture, demonstration, Experimentation, Tutorial, Problem solving, Self-learning

Evaluation criteria: Continuous Assessment **(10 Marks):** Based on attendance in practical class, practical record, involvement in practical, etc.

End Semester Exam: Subjective Type Test (**40 Marks)** (30 Marks practical performance and 10 Marks viva)
Total Marks: 50

Interdisciplinary Courses

Course Title: Waste Management in Our Daily life
Paper Code: EVS.532

L	T	P	C
2	0	0	2

Total teaching hours: 30 h

Learning Outcomes: The students should be able to:

- Learn different types of waste
- Various waste management option
- Issues and concerns of waste

Unit 1: Waste (7 Lectures)

What is waste? Sources of waste generation; Composition and classification of waste; Sorting and segregation of waste at source of generation (kitchen, garden, residential colonies and commercial areas); waste collection – sample collection bins; storage and transport; Group Discussion, Student generated Questions, Case Studies.

Unit 2 Waste processing and prevention (8 Lectures)

Waste prevention and recycling at home, small communities; reduce, recycle and reuse; Waste processing – size and volume reduction; Group tasks-assignments, Case Studies.

Unit 3: Waste treatment (8 Lectures)

Composting – vermicomposting, kitchen garden; anaerobic digestion – biogas, manure; waste to energy – pyrolysis, refuse derived fuels; Group Discussion, Case Studies, Debate,Think- Pair-Share method.

Unit 4: Disposal of waste (7 Lectures)

Safe disposal of waste; open dumping, problems of open dumping and burning; landfills; diseases associated with waste handling; Best practices for solid waste disposal; Student generated Questions, Group tasks-assignments, Case Studies, Debate.

Suggested Readings:

1. Ramachandra, T.V., (2009). *Management of municipal solid waste*, published by TERI Press, New Delhi
2. Dhamija, U. (2009). *Sustainable solid waste management: issues, policies, and structures*. Academic Foundation, New Delhi.
3. Williams, P. T. Williams A. (2005). *Waste treatment and disposal*, 2nd Edition Wiley publications, UK.

Suggested Websites:

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

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Environmental Conservation
Paper Code: EVS.533

L	T	P	C
2	0	0	2

Total teaching hours: 30 h

Learning Outcomes
Student will be able to:

- Analyse need and scope of environmental conservation
- Demonstrate methods of soil and water conservation
- Illustrate the approaches for biodiversity conservation
- Assess the ways to conserve energy at different sectors

Unit 1: Introduction to global environmental issues (7 Lectures)

Environment- Atmosphere, Hydrosphere, Lithosphere, Biosphere; Global environmental issues- global warming, Acid rain, Ozone depletion, Photochemical smog, Asian brown clouds; Importance of environmental conservation, waste as a resource; Group Discussion, Student generated Questions, Think- Pair-Share method.

Unit 2: Soil and Water conservation (8 Lectures)

Land resources; Land degradation; Soil Pollution; soil erosion, conservation measures; Soil fertility restoration.

Water resources; water pollution- river, ground water; need for sustainable water management, Micro irrigation techniques, watershed management, rain water harvesting; Student generated Questions, Group tasks-assignments, Case Studies, Think- Pair-Share method, Jigsaw method.

Unit 3: Biodiversity conservation (8 Lectures)

Biodiversity; significance of biodiversity conservation, threats to biodiversity, man- wildlife conflicts, strategies for biodiversity conservation; Forest and wildlife conservation; Group Discussion, Student generated Questions, Group tasks-assignments, Case Studies, Jigsaw method.

Unit 4: Energy conservation (7 Lectures)

Energy resources- renewable and non-renewable energy sources; Energy conservation- home, buildings; energy efficiency – electrical appliances; CFL, LEDs, OLEDs, clean fuels for vehicles; Group Discussion, Student generated Questions, Case Studies, Debate,Think- Pair-Share method, Interactive demonstration.

Suggested Readings:

1. Arumugam, T., Sapna, K. (2020). *A Text Book of Environmental Science*, Walnut Publication, Bhubaneswar.
2. Das, S. K. (2018). *Watershed Development and Livelihoods: People's action in India*, Routledge India. New Delhi.
3. Singh, S. P., Singh, J. S. (2017). *Ecology Environmental Science and Conservation*, S. Chand (G/L) & Company Ltd., Chandigarh.
4. Rajagopalan, R. (2015). *Environmental Studies*. Oxford University Press, United Kingdom.
5. Ahluwalia, V. K. (2013). *Environmental Studies: Basic concepts*, TERI, New Delhi.
6. Fatik B. M., Nepal, C. N. (2013). *Biodiversity: concepts, conservation and biofuture*, Asian Books Pvt. Ltd, New Delhi.
7. Prasad, G. (2013). *Conservation of Natural Resources*, Discovery Publishing, New Delhi.
8. Fa, J. E. (2011). *Zoo Conservation Biology* (Ecology, Biodiversity and Conservation), Durrell Wildlife Conservation Trust, Cambridge University Press, United Kingdom
9. Misra, S. P, Pandey, S. N. (2010). *Essential Environmental Studies*. Ane Books Pvt. Ltd., New Delhi.
10. Burchett, S. (2010). *Introduction to wildlife conservation in farming*, Wiley- Blackwell, United States.
11. Bhatt, S. (2004). *Environment protection and sustainable development*, APH Publishing Corporation, New Delhi.

Suggested Websites:

1. http://envis.nic.in/ENVIS_html/ENVISSubject/subject.html
2. https://www.iucn.org/
3. https://www.cbd.int/

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Environmental Geology
Paper Code: EVS.535

L	T	P	C
2	0	0	2

Total teaching hours: 30 h

Learning outcomes: The students should be able to

- Understand the soil forming process and water-rock interaction that drive chemical compositions in soil and waters;
- Understand geologic hazards and explain how the human activities contribute to natural disasters;
- Analyse the geogenic and anthropogenic cause of soil and water pollution and ways to prevent pollution
- Identify the current environmental issues in India and possible solutions

Unit I: Fundamental of Environmental Geology (7 lectures)

Concept and principle of Environmental Geology. Domains of the Earth: lithosphere, hydrosphere, atmosphere, biosphere. Soils and minerals: Formation of soils, soil weathering, types of soils, soil profiles, composition of soil, rocks types, and minerals, source of natural waters, water-rock interactions; Student generated questions.

Unit II: Environmental Pollution (8 lectures)

Definition of environmental pollution and its types - point and non-point sources. Physical, chemical and biological characteristics of water and soil. Source, cause and effect water and soil pollution. Geogenic contamination (As, F, U). Interactions between anthropogenic activities such as industrialization, urbanization, agriculture, and mining and environment. Prevention of pollution; Group discussions.

Unit III: Natural hazards (8 lectures)

Concept and principles of natural hazards and disasters such as floods, droughts, earthquake, cyclones and landslides. Humans add to natural disaster; Man-made disasters, (wildfire, radioactive pollution, dam failure). Case studies in India. Disaster mitigation and management; Group assignments

Unit IV: Current Environmental Issue and possible solutions (7 Lectures)

Global warming, Acid rain, Ozone layer depletion. Acid Mine drainage (AMD), Groundwater contamination with arsenic and fluoride, Water stress and water scarcity, River interlinking conflict in India, Use of plastic, Narmada Dam, Tehri Dam, Soil Erosion, Deforestation; Debate, Student generated questions.

Suggested Readings:

1. Montgomery, C. W. (2020). *Environmental Geology* (7th Edition), New York, NY: McGraw-Hill Education

2. Gupta D. K., Chatterjee, S., (2018). *Arsenic Contamination in the Environment*: The Issues and Solution, Springer, end edition.
3. Scheibe, T. D., Mays, D. C. (2018). *Groundwater contamination and remediation*, MDPI.
4. Arora, S. (2018). *Environmental issues & challenges in India*. Shrinkhala Publishing House
5. Bennet, M. R., Doyle P (2016). *Environmental Geology: Geology and Human Environment*. John Wiley & Sons.
6. Gill, R. (2015). *Chemical Fundamentals of Geology and Environmental Geosciences*. Wiley Blackwell.
7. Abel, D. C., (2014). *Environmental Geology Today*. Jones & Bartlett learning.
8. Andrew, D. W., Dorothy, M., Kirsten M. (2014). *Environmental Geology: An Earth Systems Approach*. Publisher: WH Freeman; 2nd ed. 2014 edition.
9. Bhattacharya, R. (2012). *Environmental Issues in India*. Pragun Publication.
10. Bell, F.G. (2007). *Basic Environmental and Engineering Geology*. CRC Press, London.
11. Barbar, W., Murk et. al., (1996). *Environmental Geology*, John Wiley & Sons, New York.

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://nptel.ac.in/courses/105/105/105105106/

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, presentation, case study

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Health and Hygiene
Paper Code: EVS.536

L	T	P	C
2	0	0	2

Total teaching hours: 30 h

Learning outcomes: The students should be able to:

- Acquire knowledge about the issues related to human health
- Explain the mode of spread of communicable and non-communicable diseases
- Identify the current national programmes on community health

Unit –I (7 Lectures)

Health and hygiene, personal health, domestic hygiene, clean food and water, cooking with care, food hygiene and kitchen safety nutrients, malnutrition and processed food, food preservation and its impact, abstaining from habit forming substances, exercise, regular sleep and relaxation; Student generated questions.

Unit –II (8 Lectures)

Community health national programmes on community health, health education; Environmental hygiene, environmental pollution, social responsibility; Group discussions.

Unit –III (8 lectures)

Disease communicable and non-communicable diseases, epidemics, endemics communicable diseases spreading (direct and indirect); Measures to prevent diseases, protection from communicable diseases by immunization, innate immunity, acquired immunity; Think-pair-share method.

Unit –IV (7 Lectures)

First aid, bleeding, nose bleed, fainting, dehydration, animal bite burns; Occupational health; Recycling and reusing the biodegradables and dry waste; Case study.

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Suggested readings

Books and Manuals:

1. Disque, K. (2020), *CPR, AED and First Aid Provider Handbook*, Satori Continuum Publishing, USA.
2. Yadav, H., Chong, M., Lan, S. (2019), *Community Health Nursing. Second Edition, Oxford University Press.*
3. Indian First Aid Manual (2016) (7th edition), *St. John Ambulance Association (India) – Indian Red Cross Society*. Available online: https://www.indianredcross.org/publications/FA-manual.pdf

4. WHO Guidelines on Hand Hygiene in Health Care (2009), World Health Organization.
5. Tillman, C. (2007), *Principles of occupational health and hygiene: an introduction.* Allen & Unwin, Australia.

Suggested Websites:

1. e-PG Pathshala is an initiative of the MHRD under its National Mission on Education through IC. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. World Health Organisation. https://www.who.int/
3. Centers for Disease Control and Prevention. https://www.cdc.gov/
4. Ministry of Health and Family Welfare, GOI. https://www.mohfw.gov.in/

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Environmental Issues and Policies in India
Paper Code: EVS.537

L	T	P	C
2	0	0	2

Total teaching hours: 30 h

Learning Outcomes: The students should be able to:

- Describe current environmental issues and concerns in India.
- Identify the magnitude of the problem, current scenario and their impacts on human health and environment.
- Enlist the various government initiatives/policies and their progress.

Unit: 1 (8 Lectures)

Air quality: major air pollutants, their impacts on human health; State of pollution in major Indian cities; Greenhouse Gas (GHG) emissions, Climate change.

Government initiatives to tackle air pollution: Central Pollution Control Board (CPCB), Continuous emissions monitoring system, National Clean Air Programme, Comprehensive Action Plan; Group Discussion, Case Studies.

Unit: 2 (7 Lectures)

Water quality: state of water pollution of major Indian rivers. Government action plans: National Water Quality Monitoring Programme, Namami Gange, and Zero Liquid Discharge. Ground water depletion and pollution; Freshwater status and conservation in India; Student generated Questions, Group tasks-assignments, Case Studies.

Unit: 3 (8 Lectures)

Municipal, plastic and electronic waste, and their disposal; Waste Management Rules.

Sanitation, open defecation, eradication of open defecation in India, community approaches to total sanitation, Swachh Bharat Abhiyan.

Degradation of land, causes and mitigation strategies and reclaiming degraded lands; Group Discussion, Student generated Questions, Case Studies, Debate

Unit: 4 (7 Lectures)

Energy situation and related environmental problems; coal & oil combustion pollution. Clean and green fuel; Pradhan Mantri Ujjwala Yojana, Ujala Yojna.

Biodiversity: man and biosphere, project tiger, Indian rhino vision; Group Discussion, Case Studies.

Suggested Readings:

1. Akitsu, T. (2019). *Environmental Science: Society, Nature, and Technology*. Jenny Stanford Publishing
2. Simon, S. J. (2018). *Protecting Clean Air: Preventing Pollution*. Momentum Press
3. Metcalf & Eddy. (2015). *Wastewater Engineering Treatment and Reuse*. Mc Graw Hill Education (India) Private Limited.
4. John, H. (2015). *Global Warming: The Complete Briefing*. Cambridge University Press.
5. Abbi, Y., Jain Shashank. (2015). *Handbook on Energy and Environment management*. The Energy Resources Institute.
6. Sinha, M., Sinha, R. K. (2016). *Swachh Bharat.* Prabhat Prakashan.

Suggested Websites:

1. https://www.ipcc.ch
2. https://www.unep.org/
3. https://cpcb.nic.in/
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
5. http://www.indiaenvironmentportal.org.in/content/about-us/

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Semester II

L	T	P	C
3	0	0	3

Course Title: Energy and Environment

Paper Code: EVS.523

Total teaching hours: 45 h

Learning Outcomes

Student will be able to:

- Explain origin and composition of fossil fuels
- Demonstrate working principles and applications of non-conventional energy sources
- Examine waste to energy conversion technologies
- Evaluate the environmental impacts of over exploitation of renewable energy sources
- Design models for maximum energy conservation in buildings

Unit 1: Conventional energy sources (11 Lectures)

Introduction to energy sources classification of energy resources-conventional and non-conventional, renewable and non- renewable, environmental implications of energy resources.

Fossil fuels (Coal, petroleum, LPG and natural gas) – origin, composition and physico-chemical characteristics and energy content, sources properties and production process; nuclear energy– fission and fusion, technologies – nuclear enrichment, nuclear reactors, Energy scenario in the world and India. Case-study.

Unit 2: Non -Conventional energy sources (11 Lectures)

Prospects of renewable non-conventional energy, introduction to solar energy, wind energy, hydel, tidal and geothermal energy. Solar collectors, applications of solar energy: Solar water heating, solar heating and cooling of buildings, solar photo-voltaics, solar distillation, solar cooking and solar ponds. Visit to nearby villages for understanding working of solar panels/collectors.

Unit 3: Bioenergy (13 Lectures)

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. Microbial fuel cell – principle, types and challenges. Group discussions on biofuels.

Unit 4: Energy conservation (10 Lectures)

Energy conservation – principles and approach, energy conservation in buildings, green buildings, solar passive architecture, eco-housing, GRIHA norms; energy audit, national and

international norms**,** Pradhan Mantri Ujjwala Yojana, Ujala Yojna, National Solar Mission, National Mission for Enhanced Energy Efficiency. Designing models to reduce energy consumption in home/building.

Suggested Readings

1. Kanoğlu, M., Çengel, Y. A., Cimbala, J. M. (2020). *Fundamentals and Applications of Renewable Energy*. McGraw-Hill Education. United States.
2. Bent, S., (2017). Renewable Energy- Physics, Engineering, Environmental Impacts, Economics and Planning, Fifth Edition. Academic Press, Elsevier Inc.
3. Abbi, Y., Jain, S. (2015). *Handbook on Energy and Environment management*. The Energy Resources Institute.
4. Bhushan, C. (2014). *State of renewable energy in India: A citizen's report*. Centre for Science and Environment, New Delhi.
5. Glassley, W. E. (2014). *Geothermal energy: Renewable energy and the environment*, 2nd edition, CRC press, London
6. Sergio, C. C. (2013). *Introduction to biomass Energy Conversions*. CRC press.
7. Prasad, S., Dhanya, M. S. (2012). *Biofuels*, New Delhi: Narendra Publishing House, New Delhi.
8. Sawhney, G. S. (2012). *Non - Conventional Energy Resources*, PHI Learning Private Limited, New Delhi.
9. Ahmed, F. Z., Ramesh, C. B. (2011). *Handbook of Renewable Energy Technology*. World Scientific Publishing Company.
10. Lal, B., Sarma, P. M., (2011). *Wealth from waste*: Trends and technologies, TERI.
11. MNRE (2011). *Griha manual volume - 3: Technical manual for trainers on building and system design optimization renewable energy application*, Ministry of New and Renewable Energy.
12. Ottmar, E., Ramón P., Youba, S., Kristin, S., Susanne, K., Timm, Z., Patrick, E., Gerrit, H., Steffen, S., Christoph, S., Patrick, M. (2011). *Renewable energy sources and climate change mitigation: Special report of the Intergovernmental Panel on Climate Change*, IPCC.
13. Zobaa, A. F., Bansal, R. (2011). *Handbook of renewable energy technology*, World Scientific Publishing Co., Singapore.
14. European Wind Energy Association. (2009). *Wind Energy- The facts: A guide to the technology, economics and future of wind power*. Routledge Publishers
15. Rathore, N. S., Panwar, N. L. (2007). *Renewable energy sources for sustainable development*, New India Publishing Agency, New Delhi.
16. Gupta, H., Roy, S. (2006). *Geothermal energy: An alternative resource for the 21st century*, Elsevier Science Ltd.
17. Tiwari, G. N. (2002). *Solar energy: Fundamentals, design, modeling and applications*, Narosa Publishers, New Delhi.
18. Sukhatme, S. P. (2000). *Solar Energy – Principles of Thermal Collection and Storage*. Tata McGraw Hill.

Suggested websites:

1. https://www.energy.gov/science-innovation/energy-sources
2. https://mnre.gov.in
3. https://beeindia.gov.in

Mode of Transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point Google meet, Google Classroom, Swayam, e-PG Pathshala,

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Environmental Pollution -II

Paper Code: EVS.529

Total teaching hours: 45 h

Learning outcomes

On completion of this course students should be able to

- Analyze the causes and effects of air pollution.
- Describe the type and nature of air pollutants,
- Explain the methods of analysis of air pollutants and instruments involved
- List the methods available for air and noise pollution control
- Outline air quality management system

Unit 1: Air Pollution (12 Lectures)

Air pollution – world and Indian scenario, Sources and classification of air pollutants, Air pollutants effects and consequences, Criteria pollutants and NAAQS, AQI.

Atmospheric Aerosols: Size Distribution, lognormal number, surface area, volume and mass distribution, dynamics, thermodynamics of aerosol and Nucleation phenomenon; Bioaerosols-types and consequences. Case study on air pollution scenario.

Unit 2: Air Pollution Modeling (11 Lectures)

Indoor and outdoor environmental monitoring; Air dispersion and Modelling**:** Plume behaviour and principles of air pollutants dispersion (Gaussian dispersion model) Plume rise estimation, Effluent dispersion theories and Atmospheric and Indoor chemical modelling, Demonstration on Measuring Indoor Air Pollution.

Unit 3: Air Pollution Control Technologies (11 Lectures)

Particulates - filters, gravitational, centrifugal-multiple type cyclones, Scrubbers and electrostatic precipitators: Equipment and collection efficiency; Adsorbents, PSA, adsorption cycle, rotary bed/fluidized bed, Condensation - contact condensers, shell and tube condenser, flaring. Gaseous Pollutants - absorption: Packed and plate columns.

Vehicular Pollution Control: Combustion Cycle, Fuel/air ratio and Catalytic convertor; selective catalytic and selective non-catalytic reduction. Visit to Nearby Industry/Power plant.

Unit 4: Noise Pollution (11 Lectures)

Definition, sources, properties of sound waves, Sound pressure, intensity, decibel, measurement and analysis of sound, Noise Indices, Sound absorption, Meteorological effects on Noise propagation, Effects and impacts on human, Noise exposure level and standards, Noise control,

Preventive measures and abatement measures. Measuring noise levels at any two sites in Campus.

Suggested Readings:

1. Tiwari, A., Williams, I. (2018). *Air Pollution: Measurements, Modelling and Mitigation*, 4th Edition, CRC Press.
2. Schnelle, K. B., Dunn, R. F., Ternes, M. E. (2017). *Air pollution control technology handbook*, Routledge Publisher.
3. Cooper, D. C. (2015). *Air pollution control*. Medtech Publisher.
4. Wayne T. D., Thad, G., Joshua S. F. (2015). *Air Quality*. CRC Press.
5. Vallero, D. A. (2014). *Fundamentals of air pollution*. 5th edition, Academic Press, USA.
6. Jacobson, M. Z. (2012). *Air pollution and global warming: History, Sciences and solutions*, Cambridge University Press.
7. Kumar, A. (2011). *Noise Pollution and its control*, New Delhi: Shree Publishers & Distributors.
8. Klein, A. (2010). *Encyclopedia of Environmental Pollution and its Control*, Apple Academic Press.
9. Wang, L. K., Pereira, N. C. (2010). *Advanced air and noise pollution control*, Humana Publisher.
10. Agrawal, S. K. (2009). *Noise Pollution*, APH Publishing Corporation.
11. Jeremy, C., Tiwary, A., Colls, J. (2009). *Air pollution: measurement, modeling and mitigation*, 3rd Edition, USA: Crc Press.
12. Rao, C. S. (2006). *Environmental pollution control engineering*, New Delhi: New Age International Publishers.
13. Cheremisinoff, N. P. (2002). *Handbook of air pollution prevention and control*, UK: Butterworth-Heinemann Publishers.
14. Kenneth Jr., W., Davis, W. T., Warner C. F. (1998). *Air pollution and its origin and control*, 3rd edition, USA: Prentice Hall.
15. Clarke A. G. (1997). *Industrial air pollution monitoring: gaseous and particulate emissions*, USA: Springer.

Suggested Websites:

1. https://www.ipcc.ch
2. https://www.epa.gov/environmental-topics
3. https://cpcb.nic.in/
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
5. https://nptel.ac.in/courses/119/106/119106008/
6. http://www.indiaenvironmentportal.org.in/content/about-us/

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: **Basics of Geospatial Technology**

Paper Code: EVS.530

Total teaching hours: 45 h

Learning Outcomes

The student will be able to:

- Identify geospatial tools- remote sensing, GIS and GPS
- Apply the concept of remote sensing and GIS for solving environmental problems
- Choose appropriate geospatial technique for environmental management

Unit I: Fundamental Concepts of Remote Sensing (12 Lectures)

History of Remote Sensing, Spectrum, Spectral Quantities, Theories of EMR; Theory of EMR: Laws of Radiation; Concept of Blackbody radiation; Electromagnetic Spectrum; Scattering, Absorption, Refraction, Path Radiance Reflection, Transmission, Absorption; Energy-Earth Interaction, Atmospheric Windows, Spectral Signatures of Surface Features; RS Satellites- Polar sun-synchronous, geo-stationary; Platforms: Types and their orbital characteristics; Sensors types: active and passive; Sensors systems: whiskbroom and push broom; Principles and geometry of scanners and CCD arrays; Satellite RS data products or series: Optical, Microwave and Hyperspectral. Video based evaluation

Unit II: Image Processing and Interpretation **(**11 Lectures)

Image: Meaning and Types (Analogue and Digital) and Characteristics; Resolution: Spatial, Spectral, Radiometric and Temporal; Basics of Image Processing; Elements of Image Interpretation; Visual Interpretation; Ground Truth Collection; Hyperspectral remote sensing; SAR and UAV. Practical demonstration of Image Interpretation

Unit III: Fundamental concept of GIS and GNSS (11 Lectures)

Concept and definition of GIS, History and development of GIS technology, Applications of GIS in various sectors; Geographic information database management system: data types (map, attributes, image data) and structure; Spatial and non-spatial data; Projection and Geo-referencing; Spatial analysis: overlay, buffer and proximity, network analysis; Introduction to GNSS; Concepts and types. Group-discussion on GIS and GNSS in different countries

Unit IV: Applications of Geospatial Technology **(**11 Lectures)

Applications in Environmental science; Geological sciences; Geographical sciences; Sustainable development Goals (SDGs); Urban Planning and Management; Disaster management**.** Case Studies. Case-studies on applications of Geospatial Technology; Think-Pair Share method

Suggested readings:

1. Singh, C. K. (2018). *Geospatial Applications for Natural Resources Management,* CRC Press.
2. Shellito, B. (2017). *Geospatial Technologies*, 4th edition, W. H. Freeman Publisher.

3. Shamsi, U. M. (2012). *GIS applications for Water, Wastewater, and Stormwater systems*, CRC Press.
4. Bhatt, B. (2011). *Remote Sensing and GIS*, New Delhi: Oxford university press.
5. Skidmore, A. (2010). *Environmental Modelling with GIS and Remote Sensing*, New Delhi, Crc Press.
6. Abbasi, T. (2010). *Remote Sensing, GIS and Wetland management*, Discovery publishing house.
7. Lillisand, T. M., Keifer, R. W. (2007). *Remote Sensing and Image Interpretation,* USA: John Willey and Sons.
8. Joseph, G. (2003). *Fundamentals of Remote Sensing*, Hyderabad: Universities Press.
9. Chang, K. (2002). *Introduction to Geographic Information Systems,* USA: Tata McGraw-Hill.
10. Barrett, E. C. and Curtis, L. F. (1999). *Introduction to Environmental Remote Sensing,* USA: Chapman and Hall Publishers.
11. Curran, P. J. (1988). *Principles of Remote Sensing,* ELBS: Harlow Longman Scientific and Technical.

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://nptel.ac.in/courses/105/103/105103193/
3. https://giovanni.gsfc.nasa.gov/giovanni/
4. https://earthobservatory.nasa.gov/

Mode of Transaction: Lecture, power point, demonstration, case study, group discussion, e-learning

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: **Environmental Management and Auditing**
Paper Code: EVS.538

Total teaching hours: 45 h

Learning outcomes

On completion of this course students should be able to:

- Explain the major principles of environmental impact assessment
- List the different steps within environmental impact assessment
- Evaluate the implications of current rules and regulations in relation to environmental impact assessment
- Outline the key aspects of environmental audit and risk analysis
- Formulate an EIA report
- Analyse different case studies of EIA in practice

Unit 1: Introduction (11 Lectures)

Environment Impact Assessment - Principles, Origin, development and history. EIA notification (1994)

EIA Methodologies

EIA Guidelines, Scope of EIA in project planning and implementation, Indian directions of EIA, Monitoring tools for EIA, surveys, spatial databases, experiments, models, methods of prediction matrices, networks, checklists and overlays and other methods of impact assessment.Systematic review by students under teacher's supervision

Unit 2: EIA notification 2006 (12 Lectures)

EIA notification 2006 and its Amendments: EIA standards and guidelines, public participation-procedure of public hearing, presentation, review and decision making. Quality control – trends in EIA practice, evaluation criteria, expert system in EIA, use of regulations. Documentation and monitoring – Generic structure of EIA Document. EIA consultant empanelment (NABET/QCI). Class assignments

Unit 3: EIA components and Case studies (12 Lectures)

Components of EIA – project screening, scoping, baseline data, impact identification, prediction, evaluation, mitigation. Assessment techniques – cost benefit analysis, analysis of alternatives etc. Terms of Reference for different type of projects as per EIA Schedule, Case-based evaluation

Unit 4: Environmental Management (10 Lectures)

Definition and types of audits, Guidelines for environmental auditing, methodologies for Environmental Auditing. Environment Quality Management system, Case studies of EIA of different sectors, Case-study

Suggested Readings

1. Khandeshwar, S. R., Raman, N. S., Gajbhiye, A. R. (2019). *Environmental Impact Assessment,* Dreamtech Press.
2. Hosetti, B. B., Kumar, A. (2013). *Environmental Impact: Assessment and Management,* New Delhi: Daya Publishing House.
3. Chitkara, M. G. (2013). *Environmental Impact Assessment,* New Delhi: APH Publishing Corporation Eccleston C. H. (2011). *Environmental Impact Assessment: a guide to best professional practices,* CRC Press.
4. Shrivastav A. K. (2011). *Environmental Impact Assessment,* APH Publishing Corporation.
5. Kulkarni, V., Ramachandra, T. V. (2009). *Environmental Management.* New Delhi: Capital Pub. Co.
6. Morris, P., Therivel, R. (2009). *Methods of Environmental Impact Assessment,* London: Routledge.
7. Fischer, T. B. (2007). *Theory and Practice of Strategic Environmental Assessment*, London: Earthscan.
8. Glasson, J., Therivel, R., Chadwick, A. (2006). *Introduction to Environmental Impact Assessment,* London: Routledge.
9. Petts, J. (2005). *Handbook of Environmental Impact Assessment*. Volume 1 and 2, UK: Blackwell Publishers.
10. Lawrence, D. P. (2003). *Environmental Impact Assessment: practical solutions to recurrent problems,* Hoboken NJ: John Wiley & Sons.
11. Wood, C. (2003). *Environmental Impact Assessment – A Comparative Review*, Prentice Hall, London.
12. Petts, J. (1999). *Handbook of Environmental Impact Assessment.* volume 1 and 2, Oxford: Blackwell Science.
13. Therivel, R., Partidario, M. R. (1996) (eds). *The Practice of Strategic Environmental Assessment,* London: Earthscan.
14. Canter, W. L. (1995). *Environmental Impact Assessment*, New York: McGraw-Hill Science/ Engineering/ Math.
15. Morris, P., Therivel, R. (1995). *Methods of Environmental Impact Assessment*, London: UCL Press.
16. Vanclay, F. Bronstein, D. A. (1995) (eds). *Environmental and Social Impact Assessment*, Chichester: Wiley & Sons.

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. http://environmentclearance.nic.in/
3. https://nptel.ac.in/courses/120/108/120108004/
4. http://www.fao.org/3/v9933e/v9933e02.htm

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Websites

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
0	0	4	2

Course Title: Environmental Pollution-II (Practical)

Paper Code: EVS.539

Total practical hours: 60 h

Learning outcomes

On completion of this course students should be able to

- Explain the methods of analysis of air pollutants
- Enlist the instruments for air pollution measurements
- Develop the analytical skills for quantitative analysis of air and noise pollution
- List the methods available for air and noise pollution control
- Design various experiments for analyzing the air pollutants

Experiments

1. Study of PM_{10} in ambient air.
2. Study $PM_{2.5}$ in ambient air.
3. Determination of SO_2, NO_x, and Cox in ambient air.
4. Study and interpret the data of continuous Ambient air quality monitoring system
5. Sampling and analysis of Noise.
6. Preparation of biodiesel and study its characteristics
   - Calorific Value
   - Viscosity
   - Flash point
   - Cloud and pour point
   - Acid value

Suggested readings

1. Gupta, P. K. (2018). *Methods in Environmental Analysis: Water Soil and Air*, 2nd Edition. Jodhpur, India: Agrobios Publication.
2. Hess-Kosa, K. (2018). *Indoor Air Quality: The latest sampling and Analytical methods*, London: CRC press.
3. Patnaik, P. (2017). *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil and Solid Wastes*, 3rd Edition, London: CRC press.
4. Lodge, J. P. (2017). *Methods of Air Sampling and Analysis*, 3rd Edition, New York: Taylor & Fransic Group.
5. Maiello, M., Hoover, M. D. (2011). *Radioactive Air Sampling methods*, 1st Edition. CRC Press Book.

Evaluation criteria: Continuous Assessment: **10 Marks**

End Semester Exam: Subjective Type Test (**40 Marks)** (30 Marks practical performance and 10 Marks viva)

Total Marks: 50

L	T	P	C
0	0	2	1

Course Title: Basics of Geospatial Technology (Practical)
Paper Code: EVS.540

Total practical hours: 30 h

Learning Outcome:

The students will be able to:

- Design various experiments for familiarization with satellite images, mapping and layout.
- Apply remote sensing and GIS software for image interpretation
- Develop the analytical skills for pre-processing, image classification and post-processing

Image Interpretation and Image Processing:

- **Satellite data mining:** downloading and familiarization of satellite imagery, reading metadata and basic characteristics of images.
- **Preprocessing:** geometric and radiometric correction, FCC generation, mosaicking, subletting and atmospheric correction
- **Image classification and interpretation:** visual interpretation, digital image processing (supervised, unsupervised and hybrid classification)
- **Post processing and accuracy assessment:** mixed pixel correction, error matrix, user accuracy, producer accuracy, overall accuracy, kappa indices.

GIS and GNSS

- **GIS database mining:** point, polygon and line features capture, editing and manipulation, topology building, joining attribute table with spatial data.
- **Vector analysis**: proximity and overlay analysis, network analysis, geostatistical analysis.
- **Mapping and layout**: map template design, map layout design based on scale, export and publishing.
- **GPS mapping:** GCP collection, tracking and mapping.

Suggested readings

1. Kennedy, M. (2013). *Introducing geographic information systems with ArcGIS: A workbook approach to learning GIS*, Wiley & Sons Publications.
2. Kennedy, M. (2010). *The Global positioning system and ArcGIS*. Crc Press.

Mode of Transaction: Lecture, demonstration, Experimentation, Tutorial, Problem solving, Self-learning, E-tutoring

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria: Continuous Assessment: **10 Marks**

End Semester Exam: Subjective Type Test (**40 Marks)** (30 Marks practical performance and 10 Marks viva)
Total Marks: 50

L	T	P	C
3	0	0	3

Course Title: Natural Resource Management
Paper Code: EVS.528

Total teaching hours: 45 h

Learning Outcomes

On completion of the course, the learner will be able to:

- Relate the importance of natural resources in the environment
- Discuss the causes of natural resource depletion
- Apply the various management strategies to protect and restore the natural resources
- Inspect various legal measures taken at the national and international level to conserve and restore natural resources

Unit 1: Forest resources (11 Lectures)

Natural resources: Definition and Classification; natural resource degradation – Environmental impacts and conservation

Forest Resources: Forest cover of India; forest types, functions of forest – production and protection; Conservation of forests; forestry programmes – social forestry, farm forestry, urban forestry, community forestry; deforestation; Afforestation; Desertification; Forest policy. Think-Pair Share method

Unit 2: Water and Marine resources (12 Lectures)

Water Resources: Surface, groundwater, marine and brackish water resources - assessment and utilization; Rivers and Lakes in India; Ground water resource depletion and salinity issues; Water Conservation and management techniques; Rain water harvesting; Watershed management; River cleaning, River action plans - Ganga and Yamuna action plan, Interlinking of rivers; conflicts over water; Jal Shakti Abhiyaan, Namami Gange, National Water Mission; Marine mineral resources - polymetallic manganese nodules, phosphorites, hydrocarbons, rare metals, corals, pearls and shells, Management of marine resources, Case studies.

Unit 3: Land and mineral resources (11 Lectures)

Land resources: Land degradation due to mining, exploration, industrialization, irrigation and natural disasters; Soil Erosion, Loss of soil fertility, Restoration of soil Fertility, Soil Conservation Methods; restoration of degraded land-CoP 14-Delhi Declaration; Wasteland reclamation, Organic farming, green manuring, Wetland – definition, classification, functions, ecological importance and conservation.

Mineral resources: Distribution of mineral resources of India – Use, exploitation and environmental impacts; Restoration of mining lands. Group discussions

Unit 4: Bioresources (11 Lectures)

Evolution strategies, adaptation, Vegetation, flora and fauna of India; Aquatic bioresource; Definition, Types and significance of biodiversity, values and threats, biodiversity conservation strategies; Bioprospecting. Biopiracy. REDD+; Conventions and protocols. Wild life resources and conservation measures

Human resources – population explosion, urbanization, industrialization, slums, poverty. Group assignments

Suggested Readings:

1. Singh, C. K. (2018). *Geospatial Applications for natural Resources Management,* CRC Press.
2. Primak, R. B. (2014). *Essentials of Conservation biology*, Sinauer Publishers, 6th edition.
3. Raju, N. J., et al., (2014). *Management of Water, Energy and Bio-resources in the Era of Climate Change: Emerging Issues and Challenges,* Springer.
4. Anderson, D. A. (2013). *Environmental economics and natural resource management,* Taylor and Francis 4th Edition.
5. Beckman, D. W. (2013). *Marine environmental biology and conservation,* Jones and Barlett learning.
6. Balyani, R. (2012). *Indian Forest and Forestry,* Jaipur: Pointer Publishers.
7. Jetli, K. N. (2011). *Mineral Resources and policy in India,* New Century Publications, Delhi.
8. Kathy, W. P. (2010). *Natural resources and sustainable developments,* Viva books.
9. Jaidev, S. (2010). *Natural resources in 21st century,* Oxford Publishers.
10. Mishra, S. P. (2010). *Essential Environmental Studies,* Ane Books.
11. Ghosh, A. (2010). *Natural resource and conservation and environment management,* Aph Publishing corp.
12. Lynch, D. R. (2009). *Sustainable natural resource management for scientists and engineers,* Cambridge University Press.
13. Grigg, N. S. (2009). *Water resources management: Principles, regulations, and cases*. McGraw Hill Professional.
14. Kudrow, N. J (Ed). (2009). *Conservation of natural resources, Nora Science,* New York.
15. Mohanka, R. (2009). *Bioresources and human Environment,* APH Publishing Corporation, Delhi.

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://www.fsi.nic.in/
3. https://www.unccd.int/

Mode of Transaction: Lecture, power point, demonstration, case study, co-operative learning, group discussion, e learning

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**

Total Marks: **100**

Course Title: Waste Management

L	T	P	C
3	0	0	3

Course Code: EVS.556

Total teaching hours: 45 h

Learning Outcomes

On completion of the course, the learner will be able to:

- Relate the sources of waste generation
- Inspect the reasons for waste generation
- Apply various treatment and disposal techniques to manage the solid waste
- Formulate new strategies for managing the solid and hazardous waste
- Assess the various legal framework of solid waste management.

Unit 1: Municipal Solid Wastes (11 Lectures)

Waste: Sources, classification of waste; Composition, collection, transportation and characterization of municipal solid wastes – proximate and ultimate analysis, transfer stations, waste processing and minimization, recycling. Group discussion, Presentation

Unit 2: Waste Treatment and Disposal (12 Lectures)

Energy from waste - Incineration, Pyrolysis, Gasification; Composting, Vermicomposting, Biogasification, refuse derived fuels.

Burning, open dumping - problems, Landfill – site selection, structure, operation and closure. Landfill bioreactors, Group discussion, Visit to biogas plant, local landfill site

Unit 3: Hazardous Wastes (11 Lectures)

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. Group assignment, Case Studies with respect to Indian states

Unit 4: Waste Handling Rules **(**11 Lectures)

Municipal waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, e waste rules, Plastics waste rules, Schemes and programmes of Government- Swachchh Bharat Abhiyaan. Group assignment, Comparison of new amendments and old rules , Case studies - Success stories on Swachchh Bharat Abhiyaan Mission in Indian states

Suggested Readings:

1. Letcher, T. M., Vallero, D. (2019). *Waste: a handbook for management,* 2nd Edition, Academic Press.Williams, P. T. (2013). *Waste treatment and disposal*, John Wiley Publishers.

2. Cherry, P. M. (2016). *Solid and Hazardous waste management,* New Delhi: BCS publishers and Distributors.Johri, R. (Ed.). (2009). *E-waste: Implications, regulations and management in India and Current global best practices,* TERI press.

3. Smith, K. (2013). *Environmental Hazards: Assessing Risk and Reducing Disaster,* Routledge Taylor & Francis group.

4. Letcher, T. M. (Ed.) (2011). *Waste: A handbook for management.* Academic Press London.

5. Rosenfeld, P. E. (2011). *Risks of hazardous wastes,* London: Elsevier.

6. Sahai, S. (2009). *Bio- medical waste management,* APH Publishing.

7. Hester, R. E. (ed.); Roy, M. H. (ed.) (2008). *Electronic waste management: design, analysis and application,* Cambridge Royal Society of Chemistry.

Suggested Websites:

1. https://cpcb.nic.in/rules-2/
2. https://nptel.ac.in/courses/120/108/120108005/
3. https://vikaspedia.in/energy/environment/waste-management/solid-waste-management-rules
4. https://swachhbharat.mygov.in/
5. http://www.indiaenvironmentportal.org.in/content/about-us/

Mode of Transaction: Lecture, power point, demonstration, case study, co-operative learning, group discussion, e learning, self-learning

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Natural Hazards and Disaster Management

L	T	P	C
3	0	0	3

Paper Code: EVS.558

Total teaching hours: 45 h

Learning outcomes:

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

- Describe disaster management, hazard, vulnerability and risk assessment.
- Deliberate how remote sensing and GIS can be used for effective management of disasters.
- Outline the legal framework for disaster management**.**

Unit I: Introduction to Natural Hazard and Disasters (11 Lectures)

Introduction to Disaster: Concept of hazards, Catastrophe and disaster; Concept of vulnerability and risk; Types of disasters: Natural (flood, cyclone, earthquake, landslides, Tsunamis; Volcanoes, Wild fires) and man-made (Oil spills; Urban hazards and disasters, Fire, Terrorism, Food poisoning, stampedes), Group assignments

Unit II: Disaster Risk Reduction and mitigation (DRRM) (12 Lectures)

Risk Assessment and Preparedness: Pre-Disaster Management activities; Hazard, Risk, vulnerability and capacity analysis (HRVCA); Hazard zonation maps: preparation and utilization; capability assessment; emergency / contingency planning and Post-disaster management activities; Development planning, planning environment, types of plans, MBO, SWOT analysis; Mitigation strategy : Relief measures, community health, casualty management Role of Government, Non-Governmental and media agencies; Reconstruction and Rehabilitation; Awareness through print and electronic media, involving youth in field observation,Case studies

Unit III: Approaches in Disaster Management (11 Lectures)

Application of Geoinformatics in Disaster Management: Role of GPS, GIS and Remote Sensing in disaster management - monitoring, tracking and modelling for disaster management; Early warning systems and Decision-making models and processes; Approaches to make Disaster management plan and field based HRVCA,Case-based evaluation

Unit IV: Legislations and Policies for Disaster Management (11 Lectures)

India Disaster Resource Network; Emergency Management and planning; Organization and structure for Emergency Management; Principles and Practice of Disaster Relief and Recovery; Disaster management policy; Command and coordination in disaster management; Important statutes with provisions relevant to Disaster Management; Scope of Disaster Management Law

with reference to Disaster Management Bill 2005, Local Administration and disaster risk reduction; Relief and Rehabilitation; CoP25-Disaster Resilience, Group discussions.

Suggested Readings

1. Kukal, S. S., Kingra, P. K. (2019). *Introduction to Environmental and Disaster Management*, Kalyani Publishers.
2. Schwab, A. K. (2017). *Hazard mitigation and preparedness: An introductory text for emergency management and planning professionals*, CRC Press.
3. López-Carresi, A., et al. (2014). *Disaster management: International lessons in risk reduction, response and recovery*, New York: Routledge.
4. Smith, K. (2013). *Environmental Hazards: Assessing Risk and Reducing Disaster*, Routledge: Taylor & Francis group.
5. Yadav, R. K., Singh, R. (2013). *Hazard Analysis and Management*. New Delhi: Oxford Book Company.
6. Vaidyanathan, S. (2011). *An Introduction to disaster managements: Natural Disasters and manmade hazards*, New Delhi: Ikon books.
7. Mullick, N. H. (2011). *Disaster Management*, Enkay Publication House, New Delhi.
8. Shaw, R., Krishnamurthy, R. R. (2009). *Disaster Management: Global Problems and Local Solutions*, Hyderabad: Universities Press.
9. Arvind, A. (2009). *Environment and disaster management*, New Delhi: Shree Publishers.
10. Jain, A. K. (2008). *A practical guide to disaster management*, Delhi: Pragun Publication.
11. Parasuraman S. (2004). *India Disasters Report: Towards a Policy Initiatives*, Oxford University Press.
12. Bohle, H. G., Downing, T. E., Watts, M. J. *Climate change and social vulnerability: the sociology and geography of food insecurity, Global Environmental Change*. No.4, pp. 37-48.
13. Goel S. L., Kumar, R. (2001). *Disaster Management*, Deep and Deep Publications
14. Collins L.R., Schneid, T. D. (2000). *Disaster Management and Preparedness*. Taylor and Francis.
15. Barbar W., Murk et. al., (1996). *Environmental Geology*, John Wiley & Sons, New York.
16. William H. D., Bruce R. M. (1986). *Geology and Engineering*, Iowa: WCB Publishers.
17. John M. W., Peter V. H., (1977). *Atmospheric Science: An Introductory Survey*, New York: Academic Press.

Suggested Websites:

1. https://mausam.imd.gov.in/
2. https://ndma.gov.in/
3. https://public.wmo.int/en/our-mandate/focus-areas/natural-hazards-and-disaster-risk-reduction

Mode of Transaction: Lecture, Demonstration, Power point, E-tutoring, discussion, assignments, case study

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Microbial Technology for Pollution Abatement

Paper Code: EVS.559

Total teaching hours: 45 h

Learning Outcomes

Student will be able to:

- Explain role of microbes in the environment
- Analyze biosensors for environmental pollution detection and monitoring
- Apply bioremediation techniques for pollution control and management of xenobiotics
- Develop eco-friendly products from metabolic processes of microorganisms
- Discuss risks and benefits of genetically modified organisms in the environment

Unit 1: Fundamentals of Environmental Microbiology (11 Lectures)

Microbial diversity in the environment, Aeromicrobiology, Drinking water microbiome and treatment, extremophiles. Microbes and biogeochemical cycles, Role of microbes in environment protection, management of resources, bioindicators, biosensors - types and applications in environmental pollution detection and monitoring, Group Discussion, Student generated Questions, Group tasks-assignment

Unit 2: Microbial Bioremediation and Biofertilizers (12 Lectures)

Bioremediation – types, advantages and disadvantages, Ex-situ and in-situ bioremediation, Bioaugmentation, biostimulation. Principles of microbiology to the degradation of contaminants, Remediation of organic and metal pollutants

Microbial metal resistance, biosorption, bioleaching and bio-beneficiation, Biomining Enhanced oil recovery. Biofertilizer- types and benefits, Microbial biopesticides, Case studies, Student generated Questions, Group tasks-assignment

Unit 3: Microbial Bioproducts (12 Lectures)

Development of biodegradable and eco-friendly products –biopolymers, bioplastics, use of microorganisms in waste treatment, Biofuel- biohydrogen, bioethanol, Microbial fuel cells.

Fermentation Technology- types of fermentation processes; Bioreactors

Primary and secondary metabolites- Alcohol (ethanol), acids, solvents, antibiotics, amino acids; Enzyme Technology- Production, recovery and their industrial applications, Group Discussion, Student generated Questions, Group tasks-assignment

Unit 4: Genetically Modified Organisms and Environment (10 Lectures)

GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC for GMO applications in food and agriculture; Environmental release of GMOs;

Transgenic plants-Pest and Disease Resistance, Herbicide resistant plants, Bt cotton, Genetically engineered insects**,** Relevance of Biosafety, Cartagena Protocol, Group tasks-assignments, Case Studies, Debate.

Suggested Readings

1. Buckley R. G. (2019). *Environmental Microbiology*, CBS, New Delhi.
2. Casida, L. E. J. R. (2019). *Industrial Microbiology*, New Age International Private Limited, New Delhi.
3. Chandra, R., Dubey, N. K., Kumar, V. (2017). *Phytoremediation of Environmental Pollutants,* CRC Press.
4. Das, S. (2014). *Microbial biodegradation and bioremediation,* Elsevier, London.
5. Peppler, H. J., D. Perlman, (2012). *Microbial Technology: Microbial processes,* Academic Press, Amsterdam.
6. Maheshwari, D. K., Dubey, R. C. (2012). *Bioremediation of pollutants,* I.K. International Publishing House, New Delhi.
7. Okafor, N. (2011). *Environmental microbiology of aquatic and waste systems*, USA: Springer.
8. Fulekar, M. H. (2010). *Bioremediation Technology: Recent Advances,* Springer, Netherlands.
9. Ronald L. C., Don, L. C. (2005). *Bioremediation: principles and applications.* Cambridge University Press, UK.
10. Kaur, J. (2007). *Organic farming for sustainability*, Ludhiana: Academic book Depot.
11. Sharma, P. D. (2005). *Environmental Microbiology,* Narosa Publishing House.

Suggested Website:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://nptel.ac.in/courses/102/105/102105087/
3. https://www.nap.edu/read/2131/chapter/3

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Geochemistry and Isotope Geology
Paper Code: EGS.521

Total teaching hours: 45 h

Learning outcome:

Upon successful completion of this course, the student will be able to

- Appraise behaviors of elements in the formation of primary and secondary rocks
- Formulate basics of isotope systematics and radioactive decay.
- Design the geochemical aspects for assessment of elements in and on Earth.
- Discuss the principles and applications of radiogenic isotope systematics to study geological processes and date rock-forming events.
- Adapt the principles and applications of stable isotope systematics.

Course Contents

Unit 1 : Geochemistry (11 Lectures)

Introduction of geochemistry and cosmo-chemistry. Abundance of elements in the solar system and chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition and evolution of atmosphere. Meteorites, classification, mineralogy, origin, significance and phenomena of fall. Assignment, Take home exercise, Group discussion.

Unit II (11 Lectures)

Geochemical classification of elements, Distribution coefficient; Behavior of major and trace including rare earth elements during magmatic crystallization. Elemental mobility in surface environment, Eh-pH diagram. Concept of geochemical-biogeochemical cycling: Minor cycle and major cycle. Chemical weathering of minerals and rocks; Assignment, Take home exercise, peer learning

Unit III : Isotope Geology (12 Lectures)

Introduction and physics of the nucleus; radioactive decay; the law of radioactive decay; principles of mass spectrometry; K-Ar method: principles, methods and applications; Ar-Ar method: principles, method and advantages: Rb-Sr method: principles, Rb-Srisochron and limitations. Sm-Nd Method: decay scheme, evolution of Nd with time, Nd model ages and application of Nd to petrogenesis; U-Th-Pb Method: decay schemes, U-Pb isochron, U-Pb mineral dating and application. Assignment, Take home exercise, project method

Unit IV (11 Lectures)

Stable isotopes and their fractionation; ratio Mass Spectrometry; principles of oxygen, carbon and sulphur isotope geochemistry and their application in Geology. Application of Cosmogenic radionuclides in the geosciences. Principles and application of Fission Track and Radiocarbon methods of dating. Assignment, Take home exercise, student seminar.

Suggested readings:

1. Gunter Faure, 1998. *Principles and applications of Geochemistry*, Prentice Hall.
2. John V. Walther, 2010. *Essentials of Geochemistry*, Jones and Bartlett Publication.
3. Claude Allegre, 2008. *Isotope Geology*, Cambridge University Press.
4. Dickin, A.P., 2005. *Radiogenic Isotope Geology*.Cambridge University Press.
5. JochenHoefs, 2015.*Stable Isotope Geochemistry*, Springer International Publishing.
6. Gunter Faure, 1986. *Principles of Isotope Geology*, Wiley.
7. Gunter Faure and Teresa M. M, 2004.*Isotopes: Principles and Applications*, Wiley.
8. Francis Albarede, 2003. *Geochemistry, An introduction*, Cambridge University Press.
9. William M. W., 2013. *Geochemistry*, Wiley-Blackwell.
10. McSween Jr. H. Y., Richardson, S. M., and Uhle, M. E., 2003.*Geochemistry:Pathways and Processes*, Columbia University Press,
11. Mason, B. and Moore, C.B., 1991. *Introduction to Geochemistry*, Wiley Eastern.
12. Krauskopf, K. B., 1967. *Introduction to Geochemistry*, McGraw Hill.

Transactional Modes: Lecture, Lecture cum demonstration, Project Method, Seminar, Co-operative learning, Focused group discussion, Team teaching, Mobile teaching, Collaborative learning, E- tutoring, Problem solving, Case analysis, Self-learning, Case based study, Experimentation.

Evaluation criteria:

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Climatology
Paper Code: **GEO.507**

Total teaching hours: 45 h

Learning outcome:

The student will be able to:

- Explain the overview of the climate system
- Enlist the processes that drive the general global as well as regional circulation.
- Analyze method of interpretation of weather symbols, and the contemporary climatic issues.

Unit 1: Fundamentals of Climatology (11 Lectures)

Fundamentals of climatology and meteorology; Earth's Atmosphere: Evolution, Structure and Composition; Solar radiation and Terrestrial radiation; Variation, distribution and effect on atmosphere; Greenhouse effect and global heat budget; Temperature: Concept, measurement, scales, daily and annual cycles of temperature; vertical distribution; world distribution. Group discussion

Unit 2: Atmosphere Dynamics (11 Lectures)

Stability and instability in atmosphere; Cloud: Type and formation; Atmospheric moisture and precipitation: Concept and measurement of atmospheric moisture; Condensation - forms of condensation; adiabatic temperature changes; Formation and types of precipitation; global distribution of precipitation. Debate, student generated questions

Unit 3: Wind Circulation (11 Lectures)

Wind circulation Models of general circulation of the atmosphere: Jet stream, Air masses and fronts, characteristics, movements, frontogenesis; Tropical cyclones; mechanism and characteristics; Genesis of Indian Monsoon and the causes of its variability; Oscillations: ENSO. Group assignment

Unit 4: Climatic Classification (12 Lectures)

Classification of climates: Empirical and generic; Climatic classification with special reference to Koppen or Thornthwaite; Urban Microclimate with special reference to cities; Indian Meteorological Department and All India Weather Forecasting. Group tasks-assignments; student generated questions

Suggested Readings:

1. Grotzinger, J. P., Jordan, T.H. (2019). *Understanding Earth*, New York: Freeman & Company.
2. Kusky, T. (2017). *The encyclopedia of earth science*, Viva book private limited.
3. Singh, S. (2017). *Physical Geography*, Allahabad: Prayag Pustak Bhavan.
4. Strahler, A.N. (2013). *An Introduction to Physical Geography*, UK: John Wiley & Sons.
5. Roy, R. (2013). *Introduction to general climatology*, New Delhi: Anmol publication private limited.
6. D. S. Lal. (2011). *Climatology*, Sharda Pustak
7. Veena (2009). *Understanding earth science*, Delhi: Discovery.
8. Critchfield, H. J. (2008). *General Climatology*, Pearson Education India.
9. Frank Press and Raymond Siever (2003). *Understanding Earth*. W.H.Freeman & Co Ltd.

Suggested website:

1. IMD: http://www.imd.gov.in/pages/main.php
2. NASA Earth Observatory: https://earthobservatory.nasa.gov/?eocn=topnav&eoci=logo
3. https://public.wmo.int/en

Mode of transaction: The course will be taught with a combination of lectures, discussion, and presentations. Case study (recent weather phenomena) will also be discussed. Students will be assigned the task to Read and interpret the all India Weather Forecast report generated by IMD available at http://www.imd.gov.in/pages/allindiawxfcbulletin.php.

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Value Added Course (VAC)

L	T	P	C
2	0	0	2

Course Title: Turning waste into product
Paper Code: EVS.503

Total teaching hours: 30 h

Learning Outcomes: The students should be able to:

- Classify wastes.
- Analyze various types of waste to product recovery

Unit: 1 (7 Lectures)

Waste: definition, types and characterization; origin and waste generation status in India, impact waste on health, livestock and environment, Student generated questions

Unit: 2 (8 Lectures)

Waste to Energy: major waste to energy conversion routes –thermochemical, biochemical and physico-chemical. Biofuels: liquid fuels, such as ethanol, methanol, biodiesel, Fischer-Tropsch diesel; and gaseous fuels, methane and hydrogen; Refuse-derived fuel, Group assignments

Unit: 3 (8 Lectures)

Waste to fertilizer: utilization of waste for fertilizer production: Animal Manure, Composting, Vermicomposting, Sewage sludge treatment; Bio fertilization in agriculture and their environmental impact, Group discussions

Unit: 4 (7 Lectures)

Waste to useful material; plastic waste: Recycling and transformation of plastic waste into useful material; methods of recycling plastic.

Case study: identify a type of waste and provide potential solutions to turn it to a value product, Case studies

Suggested Readings:

1. Rogoff, M., Screve, F. (2019). *Waste-to-Energy: Technologies and Project Implementation*. Academic Press.
2. Letcher, T. M.; Vallero, D. A. (2019). *Waste: a handbook for management*. Academic Press.
3. Polprasert, C., Koottatep, T. (2017). *Organic Waste Recycling: Technology, Management and Sustainability*. IWA Publishing.
4. Ramachandra T.V. (2009). *Management of municipal solid waste*. TERI Press

Suggested Websites:

6. https://nptel.ac.in/courses/120/108/120108005/
7. https://vikaspedia.in/energy/environment/waste-management/solid-waste-management-rules

8. https://swachhbharat.mygov.in/
9. http://www.indiaenvironmentportal.org.in/content/about-us/

Mode of Transaction: Lecture, demonstration, Power point, discussion, assignments
Tools: Google meet, Google Classroom, YouTube, Slide share, Google Apps, Websites

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Semester III

L	T	P	C
3	0	0	3

Course Title: Instrumental Methods of Analysis

Paper Code: EVS.552

Total teaching hours: 45 h

Learning Outcomes:

Student will be able to:

- Explain principle, instrumentation and application of instruments
- Distinguish steps and working principle of electrochemical, spectrometric and thermogravimetric methods
- Describe the types, principle and applications of chromatographic techniques

Unit 1: Electrochemical methods (9 Lectures)

pH meter, Conductivity meter, TDS meter, DO meter, Salinity meter; Voltammetry method-Anode stripping voltammetry, Group discussions, Visit to Departmental laboratory, Interactive demonstrations of instruments

Unit2: Spectrometric Methods (13 Lectures)

U.V. spectrophotometer, Flame photometry, Atomic absorption and atomic emission spectrophotometry, Microwave-plasma Atomic Emission Spectroscopy (MP-AES); Inductive Coupled Plasma Mass Spectroscopy (ICP-MS), Group discussions, Visit to Departmental laboratory, Interactive demonstrations of instruments

Unit 3: Chromatographic Techniques (13 Lectures)

Principle and applications - Paper, Column, Thin Layer, High Performance Thin Layer Chromatography (HPTLC), Gas Chromatography (GSC and GLC), Gas chromatography–mass spectrometry (GC-MS), High Pressure Liquid Chromatography, Ion Exchange chromatography (IC), Group discussions, Visit to Central Instrumentation Laboratory, Interactive demonstrations

Unit 4: Other Analytical Techniques (10 Lectures)

Thermogravimetric Analysis (TGA, DTA), Bomb Calorimeter, Total Organic Carbon analyzer, X-ray powder diffraction (XRD), Particle size analyzer, Scanning Electron Microscopy (SEM), Group discussions, Visit to Departmental laboratory, Interactive demonstrations of instruments

Suggested readings:

1. Hussain, C. H., Kecili, R (2020). *Modern Environmental Analysis Techniques for Pollutants*, Elsevier Book, ISBN: 9780128169346.
2. Ahluwalia V. K. (2015). *Instrument Methods of chemical analysis,* Ane Books Pvt. Ltd.
3. Holler F. J., Crouch, S. R. (2014). *Skoog & West's Fundamental of Analytical Chemistry,* 9th edition, CENGAGE learning.
4. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis,* Himalaya Publishing House, New Delhi
5. Patnaik, P. (2010). *Handbook of environmental analysis*, CRC Press, USA

6. Rouessac, F., Roussac, A. (2008). *Chemical analysis: modern instrumentation and techniques*, Wiley, England.
7. Skoag, D. A., Holler, F. J., Crouch, S. R. (2007). *Principles of Instrumental Analysis*, CENGAGE Learning.
8. Skoog D. A., Holler, F. L., Crouch, S. R. (2007). *Principles of instrumental analysis*, USA: Thomson Brooks/Cole Publishers.
9. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.
10. Eaton, A. D., Clesceri, L. S., Rice, E. W., Greenberg, A. E. (2005). *Standard methods for examination of water and wastewater*, 21st Edition. American Public Health Association, American Water Worker Association, Water Environment Federation, USA.
11. Wiersma, G. (2004). *Environmental monitoring*, CRC Press, UK.
12. Svehla, G. (1996). *Vogel's qualitative inorganic analysis, 7th Edition*, Prentice Hall, USA
13. Shukla, S. K., Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment*, New Delhi: Commonwealth Publishers.
14. Ewing, G. W. (1985). *Instrumental methods of chemical analysis, 5th edition*, USA: McGraw Hill Publications
15. Harris, D. C. (1948). *Exploring Chemical Analysis*, 3rd edition. W. H Freeman & Company.

Suggested Websites:

1. https://www.agilent.com/
2. https://chem.libretexts.org/Bookshelves/Environmental_Chemistry
3. https://www.shimadzu.com/

Mode of Transaction: Lecture, demonstration, Power point, E-tutoring, discussion, assignments, case study

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

Course Title: Research Methodology

L	T	P	C
3	0	0	3

Paper Code: EVS.561

Total teaching hours: 45 h

Learning Outcomes

Student will be able to

- Formulate research problem and steps involved in research process
- Analyze types of databases and quality of research
- Apply principles and steps in acid base titrations, precipitation and complexation
- Explain principle, instrumentation and application of instruments and techniques

Unit 1: Introduction (11 Lectures)

Meaning and importance of research, Research approaches; types of journals- open access, hybrid, merits and demerits of publishing in different types of journals, concept of citations, impact factor, *h*-Index, I-10 index etc. Group tasks-assignments, One minute presentation

Unit 2: Data Collection and Research Design (12 Lectures)

Web-based literature search engines- Google Scholar, Scopus, Web of Science etc., Review of Literature, identifying gap areas for literature review, hypothesis testing, types of research design, Basic principles of experimental designs, Important Experimental designs. Group discussion, One minute presentation

Unit 3: Scientific Writing (11 Lectures)

Scientific writing, Writing research/review paper and book chapter, Poster preparation and presentation, Dissertation. writing, Reference writing and management.Group tasks-assignments, Interactive demonstrations

Unit4: Tools in Research (11 Lectures)

Plagiarism and similarity search, Use of tools like Urkund, Turnatin/Ithenticate, Reference Manager – endnote, Mendeley, Statistical and graphical tools,Group tasks-assignments, Interactive demonstrations

Suggested Readings:

1. Paltridge, B., Starfield, S. (2019). *Thesis And Dissertation Writing In A Second Language,* Routledge Publisher.
2. Hofmann, A. H. (2019). *Scientific Writing and Communication: Papers, Proposals, and Presentations,* Oxford Univ Pr; 4th edition, USA.

3. Kothari, C. R., Garg, G. (2019). *Research Methodology: Methods And Techniques*, New Age International Publishers; Fourth edition, India.
4. Prathapan, K. (2019). *Research Methodology for Scientific Research*, Dreamtech Press, India
5. Kothari, C. R. (2008). *Research methodology(s)*. New Age International, New Delhi.
6. Patnaik, P. (2010). *Handbook of environmental analysis*, CRC Press, UK.
7. Skoog D. A., Holler F. L. Crouch, S. R. (2007). *Principles of instrumental analysis*, Thomson Brooks/Cole Publishers, Australia.
8. Eaton, A. D., Clesceri, L. S., Rice, E. W., Greenberg, A. E. (2005). *Standard methods for examination of water and wastewater 21st Edition.* American Public Health Association, American Water Worker Association, Water Environment Federation, USA.
9. Gupta, S. (2005). *Research methodology and statistical techniques*, Deep and Deep Publications (P) Ltd. New Delhi.
10. Wiersma, G. (2004). *Environmental monitoring*, CRC Press, UK.
11. Katz, M. (1977). *Methods of air sampling and analysis*, *2nd edition*, American Public Health Association, USA.
12. Shukla, S. K., Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment*, Commonwealth Publishers, New Delhi.
13. Svehla, G. (1996). *Vogel's qualitative inorganic analysis, 7th Edition*, Prentice Hall, USA.
14. Ewing, G. W. (1985), *Instrumental methods of chemical analysis, 5th edition*, McGraw Hill Publications, USA.

Suggested Websites:

1. https://www.open.edu/openlearn/money-management/understanding-different-research-perspectives/content-section-8
2. https://www.modares.ac.ir/uploads/Agr.Oth.Lib.17.pdf
3. https://research-methodology.net/

Mode of Transaction: Class room teaching, assignment, Lectures, Group discussions, presentation, quiz competition.

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Statistical Methods and Data Analysis

Paper Code: EVS.562

Total teaching hours: 45 h

Learning Outcomes: The learner will be able to:

- Apply the statistics as a tool to interpret the data
- Design the experiment for research purpose
- Analyze the sampling techniques for data collection
- Choose appropriate statistical technique for data representation

Unit 1 (12 Lectures)

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart. Group tasks-assignments, Interactive demonstrations

Unit 2 (11 Lectures)

Measures of central tendency- mean, mode and median; Measures of dispersion- range, standard deviation, variance, box and whisker plots; Moments, skewness and kurtosis. Group tasks-assignments, Interactive demonstrations

Unit 3 (11 Lectures)

Sampling and Study Design; Random experiments, Elementary Probability Theory; Conditional Probability; Combinatorics Analysis- Permutations and Combination; Binomial, Normal and Poisson's distribution. Group tasks-assignments, Interactive demonstrations

Unit 4 (11 Lectures)

Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots; curve fitting; Hypothesis testing. Group tasks-assignments, Interactive demonstrations

Suggested Readings

1. Gupta, S. C. (2019). *Fundamental of Statistics,* Himalayan Publisher.
2. McClave, J. (2018). *Sincich Statistics,* Pearson Publisher.
3. Hogg, R. V., Craig, A. T. (2018). *Introduction to mathematical statistics,* Macmillan Pub. Co. Inc.
4. Murray, R. S., Larry, S. (2017). *Schaum's Outline of Statistics,* McGraw-Hill Education (ISE Editions).

5. Sheldon M. R. (2017). *Introductory to Statistics,* Academic Press, Elsevier.
6. Rohtagi, V. K. (2015). *An introduction to probability and statistics*, Wiley India private limited.
7. Mohanty, P. K., Patel, S. K. (2015). *Basic statistics,* New Delhi: Scientific Publishers.
8. Croxton, F. E. and Cowden, D. J. (2014). *Applied General Statistics,* Taylor & Francis group.
9. Carlson, K. A., Winquist, J. R. (2014). *An introduction to statistics: an active learning approach,* New Delhi: Saga publication limited
10. Meyer, P. L. (2007). *Introductory Probability and Statistical Applications,* Oxford & IBH Publishers.

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://www.emathzone.com/tutorials/basic-statistics.html

Mode of Transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
2	0	0	2

Course Title: Redrafting Environmental Science

Paper code: EVS.563

Total teaching hours: 30 h

Learning Outcome:

Student will be able to:

- Evaluate the knowledge gained on management measures of air, water, soil and noise
- Prepare for NET and other competitive examinations

Unit 1: Environmental Pollution (8 Lectures)

Types, sources and impacts of water pollution. Water quality analysis; Indian standards for drinking water (IS:10500, 2012). Drinking water and wastewater treatment.

Components of soils, minerals, soil formation, erosion, properties, soil types, biogeochemical cycles, soil pollution control, management and analysis.

Indian National Ambient Air Quality Standards; dispersion of air pollutants - Gaussian plume model, line source model and area source model.

Noise Pollution: Sources, effects, noise indices (Leq, L10, L90, L50, LDN, TNI); Noise control and abatement measures, Group tasks-assignments, Student generated questions, Quiz

Unit 2: Environmental biology and Geosciences (8 Lectures)

Sun as energy source, fossil fuels, nuclear energy, Renewable energy sources- solar energy, hydro-power, tidal energy, ocean thermal energy conversion, wind power, geothermal energy, bioenergy – Principle and applications. Radiation Budget

Major concepts in Ecology, Ecosystem Dynamics- structure, function, types and characteristics, energy flow models, biomes. Population ecology, Community ecology, Biodiversity and its Conservation, Environmental Biotechnology, Climate of India, Group tasks-assignments, Student generated questions, Quiz

Unit 3: Environmental management and Legislations (7 Lectures)

Environmental Impact Assessment (EIA)- Objectives, methodologies, Risk Assessment, Environmental Laws in India, Environmental Conventions and Agreements, Current Environmental Issues in India

Natural Hazards and Disaster Management, Indian Monsoons, Principles and Applications of remote sensing and GIS, Group tasks-assignments, Student generated questions, Quiz

Unit 4: Waste management and Environmental analysis (7 Lectures)

Solid waste collection and transportation; Solid waste processing and recovery; Waste treatment and disposal of solid wastes; Hazardous waste, e waste, plastic waste, fly ash, biomedical waste management. Titrimetry, gravimetry, spectrophotometry and chromatography, Group tasks-assignments, Student generated questions, Quiz

Suggested Websites:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. https://nptel.ac.in/course.html

Mode of transaction: Power point, E-tutoring, discussion
Tools: Google meet, e-PG Pathshala, YouTube, Websites

Evaluation criteria:
Mid Semester: Objective Type Tests: 50 marks
End Semester: Objective Type Tests: 50 marks
Total Marks: 100

L	T	P	C
1	0	0	1

Course Title: Entrepreneurship

Course Code: EVS.564

Total teaching hours: 15 h

Learning Outcomes: On the completion of this course, the learners will:

- Understand the basic concepts of entrepreneur, entrepreneurship and its importance.
- Aware of the issues, challenges and opportunities in entrepreneurship.
- Develop capabilities of establishing environmental testing laboratories.
- Know the availability of various institutional supports for making a new start-up.

Unit – 1 **(**4 Lectures)

Introduction to entrepreneur and entrepreneurship: Characteristics of an entrepreneur; Characteristics of entrepreneurship; Types of entrepreneurial ventures in Environment Science and Technology, Group tasks-assignments, Case Studies-Success stories

Unit – 2 **(**3 Lectures)

Opportunities for environmental entrepreneurship, legal requirements for establishing a new unit, raising of funds, and establishing the venture - Project report preparation – format for a preliminary project report, format for a detailed/final project report. Group Discussion, Case Studies, Sharing innovative ideas

Unit – 3 **(**4 Lectures)

Establishment of environmental testing laboratory: Infrastructural requirements, Legal provisions of recognition laboratories, Accreditation of environmental laboratories, procedure of NABL accreditation, procedure for recognition from State and central Government agency, certification procedure (ISO 14001), Guidelines for recognition of laboratory under the Environment (Protection) Act, 1986. Group tasks-assignments, Case Studies

Unit – 4 **(**4 Lectures)

Establishment of environmental consultancy: Different type of consultancy, Environmental impact assessment, recognition of a EIA consultant organizations, QC/NABET regulations for accreditation of consultancy (ISO 9001), Group tasks-assignments, Presentation

Suggested Readings:

1. Desai, Vasant (2019). *Management of a Small Scale Industry*, Himalaya Publishing House.
2. Chandra, Prasaaan (2018). *Project Preparation, Appraisal, Implementation*, Tata Mc-Graw Hills.
3. Jain, P. C. (2015). *Handbook of New Entrepreneurs*, Oxford University Press.
4. Srivastava, S. B. (2009). *A Practical Guide to Industrial Entrepreneurs*, Sultan Chand & Sons.
5. Arora, Renu (2008). *Entrepreneurship and Small Business*, Dhanpat Rai & Sons Publications.

Suggested Websites:

1. https://nptel.ac.in/courses/110/106/110106141/
2. https://startupsusa.org/

Mode of Transaction: Powerpoint, Discussion, e-tutoring

Tools: YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Mid Semester: Objective Type Tests: 25 marks
End Semester: Subjective Type Tests: 25 marks
Total Marks: 50

Course Title: Instrumental Methods of Analysis (Practical)

L	T	P	C
0	0	4	2

Paper Code: EVS.565

Total practical hours:60 h

Learning Outcomes

On completion of the course the student will be able to

- Apply principles and steps in precipitation, complexation and titrations
- Introduce acid base equilibria
- Explain principle, instrumentation and application of instruments (MP-AES, IC, TOC, Viscometer, Bomb calorimeter)
- Distinguish steps and working principle of spectrometric and thermogravimetric methods
- Describe the types, principle and applications of chromatographic techniques
- Demonstrate properties of fuel samples

Practical's/Demonstration

1. To determine fluoride in water using spectrophotometer
2. To determine Pb in water using anodic stripping voltameter
3. Sample preparation and analysis using:
4. Microwave digestion system
5. TOC analyzer
6. AAS
7. MP-AES
8. IC chromatography
9. Determination of Gross Calorific Value of fuel/straw samples using Bomb Calorimeter.

Suggested Readings

1. George E. Totten, RJ Shah, SR Westbrook. (2019). *Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing*, 2nd Edition, ASTM International
2. Ahluwalia V. K. (2015). *Instrument Methods of chemical analysis,* Ane Books Pvt. Ltd.
3. Holler F. J, Crouch S.R. (2014). *Skoog & West's Fundamental of Analytical Chemistry,* 9th edition, CENGAGE learning.
4. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis,* New Delhi: Himalaya Publishing House
5. American Public Health Association (APHA) (2012). *Standard method for examination of water and wastewater,* 22nd edn. APHA, AWWA, WPCF, Washington.

6. Yadav, M. S. (2008). *Instrumental methods of chemical analysis*, Campus Books International. Delhi.
7. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.
8. APHA (2005). *Standard methods for the examination of water and wastewater*, 21sted. Washington, DC, New York: American Public Health Association; 2005.
9. Shukla, S. K., Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment*, New Delhi: Commonwealth Publishers.

Mode of Transaction: Class room teaching, Practical and demonstration

Evaluation criteria:

Continuous Assessment: **10 Marks**

End Semester Exam: Subjective Type Test (**40 Marks)** (30 Marks practical performance and 10 Marks viva)
Total Marks: 50

L	T	P	C
3	0	0	3

Course Title: Environmental Nanotechnology
Paper Code: EVS.527

Total teaching hours: 45 h

Learning Outcomes
On completion of the course, the learner will be able to:

- Relate the concept of nanotechnology and nanomaterials
- Choose appropriate methods for synthesis and characterization of nanomaterials
- Apply the technology of nanomaterials to environmental applications
- Inspect the fate and impacts of nanomaterials on environment and health

Unit 1: Synthesis and Advanced Characterization of Nanomaterials (11 Lectures)

Nanotechnology and nanomaterials; Top down and bottom-up approach; Types of nanomaterials - Carbon-based materials, Metals and metal oxides, Q-dots, Polymeric nanowires-dendrimers and conductive polymers; Synthesis through physical, chemical, biological and mechanical routes; Properties of nanoparticles; Surface modification,Group assignment, Case studies

Unit 2: Characterization of nanomaterials (12 Lectures)

Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy, Optical Absorption and Emission Spectroscopy, XPS – Working Principle, Instrumentation and Applications X-ray diffraction - Raman Spectroscopy and its Applications – Dynamic Light Scattering (DLS). Group Discussion, Visit to Laboratory, demonstration

Unit 3: Nanomaterials in Environment (11 Lectures)

Nanotechnology for water remediation and purification; Nanomembranes; Nanoadsorbents; Nanocatalysts, Nanomaterial application in fuel cells; Nanosensors; Nanoremediation and Nanobioremediation; Nanomaterials for carbon capture. Group Discussion, Case studies

Unit 4: Environmental Nanotoxicology (11 Lectures)

Fate of nanomaterials in environment, environmental life cycle of nanomaterials, environmental and health impacts of nanomaterials, toxicological threats, eco-toxicology, Ethical issues and safety issues. Group Discussion, Student generated Questions

Suggested Readings:

1. Pillai, S. C., Lang, Yvonne, L. (2019). *Toxicity of Nanomaterials: Environmental and Healthcare Applications,* CRC Press.

2. Nouailhat, A. (2015). *An introduction to nanoscience and nanotechnology,* Wiley India.
3. Theodore, L., Kunz, R. G. (2013). *Nanotechnology: Environmental implications and solutions,* New Delhi: Wiley & Sons inc.
4. Balaji S. (2010). *Nanobiotechnology,* Chennai: MJP Publishers.
5. Poole, C. P. Jr., Owens F. J. (2009). *Introduction to nanotechnology,* New Delhi: Wiley India.
6. Lead, J., Smith, E. (Ed.). (2009). *Environmental and Human impacts of nanotechnology,* Wiley.
7. Hornyak, et al. (2009). *Fundamental of Nanotechnology,* London: CRC Press.
8. Rubahn, H. G. (2008). *Basics of nanotechnology,* Weinheim: Wiley-VCH.

Suggested Websites:

1. https://nptel.ac.in/courses/113/106/113106093/
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14

Mode of Transaction: Lecture, power point, demonstration, e learning, Tutorial

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Ecotoxicology and Occupational Health

Paper Code: EVS.557

Total teaching hours: 45 h

Learning Outcomes

On completion of the course, the learner will be able to:

- Relate the sources of environmental toxicants and their effects
- Inspect the routes of entry of different environmental toxicants
- Explain the techniques of toxicant monitoring
- Apply different prevention and control measures to ensure safety against occupational hazards

Unit 1: Introduction to Toxicology (12 Lectures)

Definitions, Classification, Toxicants in air, water, soil & their effects; Basic Probit analysis; mechanism of toxicity - Acute, sub-acute, chronic, dose effect, LD 50, LC 50 and response safe limits; IT, IC, LD_{80}, LD_{90}, LCIC, Dose response relationship, concentration response relationship; Influence of route of administration; determination of toxicity of chemicals. Group Discussion, Student generated Questions

Unit 2: Toxic Mechanisms (11 Lectures)

Bioaccumulation, bioconcentration, biotransformation and Biomagnification of toxic materials in the food chain, detoxification; Toxicology of major pesticides and heavy metals (Aluminium, arsenic, cadmium, chromium, lead and mercury). Group Assignment, Student generated Questions, case studies

Unit 3: Bioassays (11 Lectures)

Concepts, types, characteristics and significance of bioassay; Bioassay test models and classification - Microbiol, algal, invertebrates and alternative toxicity tests; Immunotoxicity, histotoxicity, cell toxicity. Group Discussion, Student generated Questions

Unit 4: Occupational Health (11 Lectures)

Occupational hazards in industries and other sectors, Safety requirements and Measures; Occupationally induced illness, non-occupational illness, Occupational diseases- Pneumoconiosis, Silicosis, Anthracosis, Byssinosis, Bagasosis, Asbestosis, Farmer's lung, Metal poisoning, Occupational cancer, Occupational dermatitis; Radiation, fire and explosion hazards; Role of WHO in occupational health. Occupational health Standards - ISO. Case studies, Student generated Questions

Suggested readings:

1. Tatiya, R. (2013). *Elements of industrial hazards: Health, safety, environment and loss prevention*, Taylor and Francis.
2. Theodore, L. (2012). *Environmental health and hazard risk assessment: Principles and calculations*, CRC Press.
3. Wong, M. H. (Ed.) (2013). *Environmental contamination: Health risks and ecological restoration*, CRC press.
4. Ware, G. M.(Ed) (2007). *Reviews of environmental contamination and toxicology*. Vol. 190: *Continuation of residue reviews*, Springer Publishers.
5. Manahan, S. E. (2013) F*undamentals of environmental and toxicological chemistry: Sustainable sciences*, CRC press.
6. Landis et al. (2011). *Introduction to environmental toxicology: molecular substructures to ecological landscapes*, CRC Press.
7. Greim H. (Ed.) (2008). *Toxicology and risk assessment: A comprehensive introduction*, John Wiley.
8. Dong, M. (2018). *An introduction to toxicology*, 4th edition, CreateSpace independent Publishing Platform.

Suggested Websites:

1. e-PG Pathshala is an initiative of the MHRD under its National Mission on Education through IC. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
2. World Health Organisation. https://www.who.int/
3. Centers for Disease Control and Prevention. https://www.cdc.gov/
4. *Ministry of Health and Family Welfare, GOI.* https://www.mohfw.gov.in/

Mode of Transaction: Lecture, power point, demonstration, case study, e learning

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
3	0	0	3

Course Title: Water and Wastewater Design and Engineering

Course code: EVS 567

Learning Outcomes: **Total teaching hours: 45 h**

The student will be able to:

- Apply modelling techniques and to determine the fate of air pollutant with respect to time and space
- Prevent and control air pollution by suitable air pollution control measures
- Design bioreactors and bioprocess controls for efficient culturing of microbes

Unit 1 Water and waste water generation (9 Lectures)

Population Forecasting, Water requirement, Rate of demand and variation in the rate of demand, Per capita consumption for domestic, industrial, public and other uses as per standards, water usage, wastewater generation – quantification of sewage; quantification of storm water; sewer networks, discussion and field visit

Unit 2 Water treatment process (12 Lectures)

Design and treatment of Surface and Ground Water for Potable Water Supply; Coagulation, Flocculation; Filtration; Disinfections; Aeration and Gas transfer; Precipitation; Softening; Adsorption and Ion exchange; Membrane processes; Construction and working of domestic Reverse Osmosis systems and commercial desalination systems, discussion and field visit

Unit 3 Wastewater treatment process (12 Lectures)

Design of wastewater treatment plants: Screen Chamber, Grit Chamber, Equalization, Activated Sludge Process, sedimentation/ Secondary, clarifier, chlorination tank, sand filters UASB reactor, Sequencing batch reactors and membrane bioreactors, discussion and field visit

Unit 4 Bioreactor and Bioprocess Design (10 Lectures)

Design principles of bioreactors; Bioreactor design Operations - Modes of operation, Types of bioreactors- Batch, fed-batch and continuous bioreactors; Components of bioreactors, Instrumentation and control of bioprocesses

Designing bioreactors: Ideal bioreactors design and analysis: Batch reactors, Fed-batch reactors, CSTR reactors, Plug-flow tubular reactor; Reactors with non-ideal mixing

Discussing different types of STP (ASP, SBR, MBR, MBBR) and ETP, discussion and field visit

Suggested Readings

1. Bailey, J and Ollis,D. (2017). Biochemical Engineering Fundamentals, McGraw Hill Education, New York
2. Shuler, M.L. and Kargi, F. (2002). Bioprocess Engineering: Basic Concepts, Prentice Hall, New Jersey
3. Gilbert M. Masters and Wendell P. Ela (2013). Introduction to Environmental Engineering and Science Pearson; 3rd edition.
4. Lee, J.M (1992). Biochemical Engineering, Prentice Hall, New Jersey
5. Metcalf and Eddy (2013), Wastewater Engineering, Mc Grill Publication
6. Noel De Nevers (2000). Air Pollution Control Engineering (2nd Edn.) McGraw Hill, New York.

Web sources:

https://nptel.ac.in/courses/105/105/105105048/

Mode of Transaction: Lecture, power point, demonstration, case study, e learning

Tools: Google meet, Google Classroom, Swayam, e-PG Pathshala, YouTube, Slide share, Google Apps, Websites

Evaluation criteria:
Continuous Assessment: **25 marks**
Mid Semester Test-1: Subjective Type Test: **25 marks**
End Semester Exam I: Subjective Type Test: **35 marks**
End Semester Exam II: Based on Objective Type Tests: **15 marks**
Total Marks: **100**

L	T	P	C
0	0	4	4

Course Title: Industrial/field visits/Internship/Project/training

Paper Code: EVS.599

Total practical hours:60 h

Learning Outcomes

On completion of the course, the learner will be able to:

- Relate the theoretical knowledge gained in lectures to practical studies in field
- Inspect the working mechanism of techniques used in industries for environmental monitoring
- Design experiments to implement theoretical and laboratory knowledge to field studies
- Choose appropriate demonstration skills for field/ action report preparation

Mode of Transaction: Field visit, observation, demonstration, Experimentation, Problem solving, Self-learning

Evaluation criteria: Report/proposal and presentation
Supervisor **(50 Marks)**
HoD and senior-most faculty of the department **(50 Marks)**:
Total Marks: 100

Semester IV

L	T	P	C
0	0	40	20

Course Title: Project/Dissertation/Training

Paper Code: EVS.600

Total practical hours:40 x 15 h

Evaluation criteria: Continuous Assessment (regularity in work, mid-term evaluation, dissertation report, presentation, final viva-voce)

Supervisor **(50 Marks)**:
External expert, HoD and senior-most faculty of the department **(50 Marks)**:
Report: 30 Marks
Presentation: 10 Marks
Final viva-voce: 10 Marks

Total Marks: **100 Marks**