Government Degree College, Baramulla (Autonomous)

Semester 8th **Major**

ENVIRONMENTAL SCIENCE
(For Honours with Research and Honours courses)

COURSE CODE: EVSC1822M/ EVSR1822M
COURSE TITLE: Instrumentation and Advanced Analytical Techniques
CREDITS: (4+2) **Credit Hours (64 + 64)**

Course Objectives

1. To provide knowledge of principles, working, and applications of modern analytical instruments.
2. To train students in spectroscopic, chromatographic, and microscopic techniques.
3. To introduce molecular and biochemical tools for environmental and biological analysis.
4. To familiarize students with advanced and emerging techniques used in research and monitoring.
5. To prepare students for independent laboratory and field-based research in environmental sciences.

Learning Outcomes

By the end of this course, students will be able to:

1. Explain the principles and applications of advanced analytical instruments.
2. Operate key laboratory instruments and interpret results.
3. Apply chromatographic, spectroscopic, and molecular biology techniques in environmental studies.
4. Integrate analytical data for water, soil, air, and biological sample analysis.
5. Critically evaluate the advantages, limitations, and emerging trends of analytical techniques.

Unit I: Spectroscopy and Microscopy Techniques

1. Colourimetry – principle, working, and applications
2. Atomic Absorption Spectrophotometry (AAS) – principle, working, and applications
3. Nuclear Magnetic Resonance (NMR) and Electron Spin Resonance (ESR) – principle, working, and applications
4. Light, fluorescence microscopes and Scanning and transmission electron microscopes (SEM, TEM) – principle, working, and applications

Unit II: Chromatography and X-Ray Techniques

1. Chromatographic techniques (paper, thin-layer, ion-exchange, column) – principle, working, and applications
2. X-ray fluorescence (XRF) and X-ray diffraction (XRD) – principle, working, and applications
3. Flame photometry – principle, working, and applications
4. Gas–liquid chromatography (GLC) and High-pressure liquid chromatography (HPLC): principle, working, and applications

Unit III: Molecular and Biochemical Techniques

1. Methods for measuring nucleic acid and protein interactions and their sequencing (Southern, Northern, Western Blotting)
2. DNA fingerprinting – principle, methods, and applications

3. Molecular markers – RFLP, AFLP, RAPD
4. Polymerase Chain Reaction (PCR) – principle, working, applications and NEXT GEN sequencing

Unit IV: Advanced and Emerging Analytical Techniques

1. Mass Spectrometry (ICP-MS), ICP–AES, LCMS, GCMS – trace metal analysis, volatile, persistent organic pollutants
2. Fourier Transform Infrared Spectroscopy (FTIR) – Principle and environmental applications
3. Biosensors and nanotechnology-based techniques for pollution detection
4. Flow cytometry and confocal microscopy – principles and applications in environmental microbiology

Practical:

1. Fluorescence Spectroscopy – Analysis of aromatic hydrocarbons or chlorophyll extracts.
2. Nuclear Magnetic Resonance (NMR). FTR and Mass Spectrometry-Interpretation of given spectra.
3. Scanning Electron Microscopy (SEM) / Transmission Electron Microscopy (TEM) – Demonstration/practice on prepared specimens (e.g., pollen grains, nanomaterials).
4. Column Chromatography – Separation of a binary dye mixture or amino acids.
5. Ion Exchange Chromatography – Demonstration of cation/anion exchange (water softening or protein separation).
6. High-Performance Liquid Chromatography (HPLC) – Estimation of caffeine from tea/coffee extract or phenols from water.
7. PCR (Polymerase Chain Reaction) – Amplification of environmental microbial DNA (demonstration).
8. Blotting Techniques (Southern, Northern, Western) – Interpretation/demonstration of given results.

Bibliography

1. Skoog, D.A., Holler, F.J., & Crouch, S.R. (2017). Principles of Instrumental Analysis. Cengage.
2. Harris, D.C. (2015). Quantitative Chemical Analysis. W.H. Freeman.
3. Christian, G.D. (2013). Analytical Chemistry. Wiley.
4. Freifelder, D. (1998). Molecular Biology. Narosa.
5. Ewing, G.W. (1985). Instrumental Methods of Chemical Analysis. McGraw Hill.
6. Khopkar, S.M. (2008). Environmental Pollution Analysis. New Age International.
7. Sharma, B.K. (2012). Instrumental Methods of Chemical Analysis. Goel Publishing House.
8. Gupta, H. (2007). Textbook of Analytical Chemistry. Pragati Prakashan.
9. Manahan, S.E. (2010). Environmental Chemistry. CRC Press (widely used in Indian PG courses).
10. Patnaik, P. (2017). Handbook of Environmental Analysis. CRC Press.