Course title: Advanced Analytical Techniques for Environmental Applications			
Course code: NRE 114	**No. of credits:** 3	**L-T-P:** 30-0-30	**Learning hours:** 60
Pre-requisite course code and title (if any): Environmental monitoring laboratory (NRE 138)			
Department: Natural and Applied Sciences			
Course coordinator:		**Course instructor:**	
Contact details:			
Course type: Elective		**Course offered in:** Semester 2	

Course Description

This course is to provide understanding of various analytical techniques and instrumental methods that students come across during their course work and research undertakings. This course begins with basic introduction of analytical technique and related terminologies. This course introduces analytical techniques along with working principal, common instrumentation and possible applications. This course will be beneficial to various fields including, environmental science, chemical science, material science and life science.

Course objective

- The objective of this course is to provide advanced skillsets of analytical techniques pertinent to environment and climate domain
- To provide scientific understanding of instrumentation, operation, interpretation of data and its applications

Course content

Module	Topic	L	T	P
1.	Spectroscopy Techniques- Electromagnetic spectrum. Quantisation of energy, Electronic, vibrational and rotational transition. Jablonski diagram, Qualitative and quantitative analysis, Beer-Lambert's law and limitations. UV-Visible spectroscopy- Principals, instrumentation, sampling and application, Fluorescence Spectroscopy, IR/Raman Spectroscopy.	5		5
2.	Atomic Spectrometry- Atomic Absorption Spectrometry/Atomic Emission Spectroscopy-Principal, Instrumentation, sampling and application, Hydride generation technique, Flame Photometry, MP-AES, ICP-OES	5		5
3.	Chromatographic Techniques- Classification of chromatographic techniques, principles and theory of chromatography. Liquid Chromatography-HPLC, Instrumentation, solvent delivery system, isocratic and gradient elution, reversed phase and normal phase chromatography, Ion Chromatography and application. Gas Chromatography- Instrumentation, carrier gas, packed and capillary columns, different detectors and applications. Introduction to hyphenated techniques.	5		5
4.	X-Ray techniques- Solids, crystal, Bravais lattice, miller indices, X-rays production, X- ray diffraction, Bragg's law, PXRD. X-ray fluorescence-principle, instrumentation and application.	5		5
5.	Electroanalytical Methods- Redox process, electrode and electrode potentials, electrochemical cells, Potentiometry, Conductometry. Polarography-Principle, half wave potential, Ilkovic equation and application.	5		5
6.	Thermal Analysis Techniques-Heat, heat capacity, thermal conductivity	5		5

	Working principle, instrumentation and application of Thermogravimetric Analysis, Differential Scanning Calorimetry and Differential Thermal Analysis.			
		30	**0**	**30**

Evaluation criteria

Test 1: 30 % (module 1and 2)-this will be open book exam where problem-based questions will be asked based on techniques taught in module 1 and 2

Test 2: 30% (module 1, 2, 3 and 4)-close book tests with focused on applications of techniques in environmental domain

Test 3: 40% (module 5 and 6)- close book tests with focused on applications of techniques in environmental domain

Learning outcomes

- To be able to handle appropriate instrumental methods for analysis. (Test 1, 2 and 3)
- Familiarity with working principals, tools and techniques of analytical techniques. (Test 1, 2 and 3)
- To understand the strengths, limitations and creative use of techniques for problem-solving. (Test 1 and 3)

Pedagogical approach

Classroom lectures, tutorials, demonstration of analytical techniques and Practical training/hand on training. Case studies based on peer reviewed research articles.

Employability:

Academic, NGO and industrial research organization.

Materials

Required text

Suggested readings

- Keith A. Smith and Malcolm S. Cresse, “Soil and Environmental Analysis Modern Instrumental Techniques”, Third Edition 2004, Marcel Dekker, Inc.
- Manahan, Stanley E. “Environmental Chemistry” Seventh Edition, Boca Raton: CRC Press LLC, 2000
- D. Harvey, “Modern analytical chemistry” (McGraw-Hill, Boston, 2000)
- Clair Sawyer, Perry McCarty and Gene Parkin, “Chemistry for Environmental Engineering and Science” 5th Edition, McGraw-Hill Higher Education.
- G. H. Jeffery J. Bassett J. Mendham R C. Denney “Vogel’s Textbook of Quantitative Chemical Analysis” Fifth Edition, 1989, Longman.
- G. Svehla “Vogel's Qualitative Inorganic Analysis” Seventh Edition, Longman.
- Paul Gabbott “Principles and Applications of Thermal Analysis” Wiley-Blackwell, 2007.
- P. J. Haines “Principles of Thermal Analysis and Calorimetry” RSC Paperbacks 2003.

Websites

- https://nptel.ac.in/

Journals

- Environmental Science & Technology - ACS Publications
- Environmental Chemistry Letters
- Peer reviewed Science and Technology Journals

Advanced Reading Material

Will be provided by instructor if require.

Additional information (if any) Please keep in mind that this course, require hands on experience to strengthen the concepts; however, this course provides supplemental material in order to communicate this information.
Student responsibilities 1. Class attendance. 2. Study of course materials as specified by the instructor. 3. Regular submission of given class assignments.

Course Reviewers:

1. Dr. Sanjeev Kumar Makin, Professor, Department of Chemistry, Director Research, Deenbandhu Chhotu Ram University of Science & Technology, Murthal-131 039.
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3. Dr. Anil K. Malik, Professor, Department of Physics, Ch. Charan Singh University, Meerut, India, Teachers' Fellow UGC, Govt. of India