Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: Research Methodology

Paper Code: EVS 901

L	T	P	C	Marks
4	1	0	4	100

Unit 1: Research Methodology

Meaning and importance of research, Critical thinking, formulating hypothesis and development of research plan, Review of literature, Interpretation of results and discussion. Library Classification systems, e-Library, Reference management, Web-based literature search engines.

(14 Lectures)

Unit 2: Scientific Writing

Technical writing: Scientific writing, Reference styles-APA, PNAS, Chicago style, Writing research paper, Poster preparation and Presentation and Dissertation.

Indexing: H-Index, G- Index, Citation

Research and academic integrity: Plagiarism, copyright issues, Intellectual property rights (IPRs).).

(14 Lectures)

Unit 3: Quantitative Analysis

Acid-Base, complexometric, argentometric, iodo- and iodimetric, redox and coulometric titrations. Gravimetric analysis – total solids, suspended solids and volatile solids. pH meter, Conductivity meter, TDS meter, DO meter, Salinity meter

(12 Lectures)

Unit 4: Instrumental Analysis and Chromatographic Technique

UV-Vis spectrophotometer, Flame photometry, Atomic absorption and atomic emission spectrophotometry, mass spectrometry.

Classical methods like paper chromatography, TLC, Column chromatography, GC, LC, IC, HPLC, GC-MS.

(16 Lectures)

Suggested Readings:

1. Eaton, A. D., Clesceri, L.S., Rice, E.W. and 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.
2. Ewing, G. W. (1985), *Instrumental methods of chemical analysis, 5th edition,* McGraw Hill Publications, USA.
3. Gupta, S. (2005). *Research methodology and statistical techniques*, Deep and Deep Publications (P) Ltd. New Delhi.
4. Katz, M.(1977). *Methods of air sampling and analysis*, *2nd edition,* American Public Health Association, USA.
5. Kothari, C.R. (2008). *Research methodology(s)*. New Age International, New Delhi. 6. Lewin, B. (2010). *Genes X*, CBS Publishers and Distributors, New Delhi.
6. Patnaik, P. (2010). *Handbook of environmental analysis,* CRC Press, UK.
7. Shukla, S. K. and Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment,* Commonwealth Publishers, New Delhi.
8. Skoog D. A., Holler F.L. and Crouch, S. R.(2007). *Principles of instrumental analysis,* Thomson Brooks/Cole Publishers, Australia.
9. Svehla G. (1996). *Vogel's qualitative inorganic analysis, 7th Edition,* Prentice Hall, USA.
10. Wiersma G.(2004). *Environmental monitoring,* CRC Press, UK

Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: Water Treatment Technologies

L	T	P	C	Marks
4	1	0	4	100

Paper Code: EVS 902

Unit 1: Introduction

Water as elixir of life, Water Pollution: Causes and Management, Drinking water, Standards for water Quality, Water analysis, water purification, Waste water & treatment technologies,

(14 Lectures)

Unit-2: Sedimentation and Ion exchange

Sedimentation: Principle and process of sedimentation, Coagulation, methods for determining Optimum coagulation dose, Flocculation process etc.

Water softening, demineralization, deionization, ion specific resins, packing of resins, resin regeneration.

(14 Lectures)

Unit-3: Adsorption

Characteristics of adsorbents like Silica gel, Zeolites, Activated carbon. Waste materials as adsorbents, research for new adsorbents, chemistry of adsorption, particle size analysis, zeta potential, adsorption kinetics, adsorption equilibrium etc. Adsorption Isotherms (Freundlich, Langmuir, BET, Kisliuk etc.), Adsorption chillers, Adsorption spillover, Polymer adsorption. Sand filter, Charcoal filter, Dual media filter, Pressure filter, filter media, Filter operation. Inclusion based removal of organic pollutants like dyes, pesticides and PCBs, polymer immobilization of host for water treatment.

(14 Lectures)

Unit-4: Reverse Osmosis

Membrane Processes, types of membrane, characterization of membranes, nano-membranes and their formation, efficiency of different membranes in removal of different elements. Chemical oxidation and precipitation. Deflurodation, iron, manganese & arsenic removal.

(14 Lectures)

Suggested Readings:

1. American Water Works Association and James Edzwald (2011). *Water Quality & Treatment: A Handbook on Drinking Water*. McGraw-Hill Professional, New York.
2. Eckenfelder, W.W. Jr., Ford, D.L. and Englande, A.J. Jr. (2009). *Industrial water quality*. McGraw-Hill, New York.
3. Eaton, A.D., American Public Health Association, American Water Works Association and Water Environment Federation (2005). *Standard Methods for the Examination of Water and Wastewater*. Washington, D. C: American Public Health Association.
4. Patnaik P. (2011). *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes.* CRC Press.
5. Rouquerol, F., Rouquerol, J., and Sing, K.S.W. (1999). *Adsorption by Powders and Porous Solids: Principles, Methodology, and Applications*. Academic Press, San Diego.
6. American Water Works Association and James Edzwald (2011). Water Quality & Treatment: A Handbook on Drinking Water. McGraw-Hill Professional, New York. Eckenfelder, W.W. Jr., Ford, D.L. and Englande, A.J. Jr. (2009). Industrial water quality. McGraw-Hill, New York.
7. Eaton, A.D., American Public Health Association, American Water Works Association and Water Environment Federation (2005). Standard Methods for the Examination of Water and Wastewater. Washington, D. C: American Public Health Association.
8. Patnaik P. (2011). Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes. CRC Press.

Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: Biological Wastewater Treatment Technologies
Paper Code: EVS 903

L	T	P	C	Marks
4	1	0	4	100

Unit 1: Introduction

An introduction to wastewater, its types, sampling methods and characterization of wastewater constituents - physical, chemical and biological; an overview of the biological wastewater treatment process and technologies

Microbiology of wastewater treatment: Role of microorganisms in wastewater, their composition and classification; microbial metabolism and their growth kinetics; Substrate removal and aerobic biological oxidation

(10 Lectures)

Unit 2: Aerobic and Anaerobic biological treatment process

Suspended (Activated sludge process), attached (trickling filter) and combined (Membrane bioreactor) growth biological treatment processes - process description, design, process control, operational problems and its applications

Anaerobic biological treatment process: Suspended (UASB, AnSBR, ABR) and attached (Attached growth anaerobic fluidized bed reactor, upflow packed bed attached growth reactor) growth biological treatment processes - process description, general design, process control, operational problems and its applications (26 Lectures)

Unit 3: Biological Nutrient removal

Nitrogen removal - Biological nitrification and denitrification - process description, microbiology & technologies; Biological phosphorus removal - process description, microbiology & technologies

(8 Lectures)

Unit 4: Biological sludge stabilization

Anaerobic digestion, aerobic digestion, composting - process description and microbiology; Sludge pre-treatment.

(12 Lectures)

Suggested readings:

1. Tchobanoglous, G., Burton, F. L. and Stensel H. D. (2003) *Wastewater engineering: treatment and reuse,* McGraw-Hill Science, USA.
2. Crittenden, J. C., Trussell, R. R. and Hand D. W. (2005). *Water treatment: principles and design,* 2nd edition, Wiley Publishers, USA.
3. Grady, C.P. Leslie, G.T. Daigger, and H.C. Lim, (1999) Biological Wastewater Treatment, Second Edition, Marcel Dekker, Inc., New York
4. Viessman. W, Jr. and Mark J. (1998) Hammer Water supply and pollution control, 6th edition, Addison Wesley Longman, Inc.

Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: Bioenergy and Bioproducts

Paper Code: EVS 904

L	T	P	C	Marks
4	1	0	4	100

Unit 1: Introduction

Bioenergy- Prospects and challenges; Types- first, second, third and fourth generation biofuels, conversion routes of biomass to bioenergy; Biodiesel production; Bioproducts-Microbial metabolites, conversion processes - Fermentation, Factors influencing metabolite production, Pathways.

(12 Lectures)

Unit 2: Fermentation for bioenergy production

Bioethanol- Ethanol production from starch, sugar; lignocellulosic ethanol- pretreatments, saccharification, enzymatic hydrolysis, fermentation; metabolic pathways; factors; ABE fermentation. Biogas - feedstocks; processes in anaerobic fermentation; properties and composition of biogas, biogas plant- components, types; factors effecting biomethane formation; Biosolids- properties and application. Biohydrogen fermentation- Hydrogen production routes from biomass- dark, photo fermentation; metabolic process; factors; advances in hydrogen production- Genetic engineering, waste water utilization; Microbial fuel cell- principle and technology; ; algal biofuel- production, benefits and challenges. (16 Lectures)

Unit 3: Biopolymers

Natural biopolymers**-** Cellulose, Protein, Nucleic acids; Biocomposites, Biofibres; Bioplastics: Types- Poly hydroxy alkanoates, Polylactic acid, Properties, Feedstocks; Production process, Biodegradation; Applications, Environmental impacts. (14 Lectures)

Unit 4: Biorefinery

Concept of biorefinery; Applications-Energy, Fuel, Chemicals; Biorefinery of lignocellulose- Products from cellulose, hemicellulose, lignin; Paper and pulp industry; Enzyme production by solid state fermentation - cellulolytic, pectinolytic, ligninolytic, amylolytic and lipolytic enzymes; Environmental importance. (12 Lectures)

Suggested readings:

- Michele Aresta, Angela Dibenedetto,Frank Dumeignil. (2012). Biorefinery: From Biomass to chemicals and fuels. Walter De Gruyter Publishers, Germany.
- Levy, S.L. (2011). Biofuels, Biorefinery & renewable energy: Issues and Developments. Nova Science Publishers, USA.
- Johnson, R.M.,Mwaikambo,L.Y. and Tucker.N. (2003). Biopolymers. Smithers Rapra Technology Publishers, United Kingdom.
- Brain McNeil and Linda Harvey. (2008). Practical Fermentation Technology. Wiley Publishers, United Kingdom.
- EIRI Board. (2010). Modern Technology of Bioprocessing (Fermentation, Food, Enzyme, Pharmaceutical Industrial, Agricultural and Energy). Engineers India Research Institute Publishers, New Delhi.
- Stansbury, P.F. (1999). Principles of Fermentation Technology, 2nd Edition. Butterworth-heinemann. Burlington, MA.
- Pandey, A., Larroche, C. and Carlos Ricardo Soccol. and Claude –Gilles Dussap. (2009). Advances in Fermentation Technology. Asiatech Publishers Inc, New Delhi.

Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: Applications of Remote Sensing and GIS in Environmental Management

L	T	P	C	Marks
4	1	0	4	100

Paper Code: EVS 905

Unit 1: Methods in Geosciences-An overview of GIS, GPS, Remote Sensing, Google Earth

Georeferencing; Digitization; Active and passive remote sensing; Types of platform; Types of orbits (Geostationary, Polar, Sun-synchronous); Scanning Systems (Pushbroom and Whiskbroom); Types of Sensors; GPS; Google Earth. (10 Lectures)

Unit 2: GIS - Basic Concepts and Spatial Analysis

Concept of space and time; Elements of GIS; Map Projection; Data structures in GIS: Raster and Vector data, Hierarchical, Network and relational data, Geo-relational and object oriented vector data structure; Vector and Raster based analysis; Overlays operations; Map algebra; Grid based operations; Buffering; Network Analysis; Terrain Analysis; Spatial analysis (Supplemented with laboratory Practicals). (14 Lectures)

Unit 3: Remote Sensing – Energy response mechanism and Digital Image Processing

Definition; Electromagnetic Radiation (EMR) spectrum; Types of Resolutions: Spatial, Spectral, Radiometric and Temporal; Spectral signatures; Energy response mechanism; Atmospheric windows; Basic geometric characteristics of aerial photographs; Scale; Resolution; overlaps; flight planning; factors governing interpretability; Elements of photo interpretation; False Colour Composite (FCC); Image Fusion; Image contrast; stretching and image filtering, Multispectral remote sensing, Remote Sensing of water and land surface features, Unsupervised and supervised classification, accuracy assessment (Supplemented with laboratory Practicals). (18 Lectures)

Unit 4: Environmental Applications of Remote Sensing and GIS

Role in environmental modelling and management; natural hazard management (floods, landslides, earthquakes); monitoring water quality and soil quality; wasteland mapping; mineral/oil exploration; resource management; Environmental Impact Assessment (EIA) studies; site-suitability analysis; land use mapping; lithological and structural mapping; hydrogeological studies and groundwater zonation mapping, role of GIS in studying air pollutants dispersal and its modelling. (14 Lectures)

Suggested Readings:

1. Congalton, Russell G., Green, Kass (2009). Assessing the accuracy of Remotely Sensed Data: Principles and Practices. Second Edition, CRC Press, Taylor and Francis Group, U.S.A.
2. Carbonneau, Patrice E., Piegay, Herve (2012). Fluvial Remote Sensing for Science and Management. John Wiley and Sons Pvt. Ltd.
3. Cooke, Millea (2013). Remote Sensing, GIS and Wetland Management. Random Exports, New Delhi.
4. Lawrence, Patrick L. Ed. (2013). Geospatial Tools for Urban Water Resources. Springer
5. Campbell, James B. and Wynne, Randolph H. (2011). Introduction to Remote Sensing. The Guilford Press,
6. Panda, B.C., (2009). Remote Sensing- Principles and Applications, Viva Books Pvt. Ltd., New Delhi

7. Wang, Guangxing, Weng, Qihao (2014). Remote Sensing of Natural Resources, CRC Press, Taylor and Francis Series in Remote Sensing Applications, U.S.A.
8. Liang, Shunlin, Li, Xiaowen , Wang, Jindi. Advanced Remote Sensing: Terrestrial Information Extraction and Application. Academic Press, Elsevier, USA.
9. Weng, Qihao (2010). Remote Sensing and GIS Integration: Theories, Methods and Application, Tata McGraw Hill, USA.
10. Yang, Xiaojun (Ed) (2011). Urban Remote Sensing: Monitoring, Synthesis and Modelling in the Urban Environment. John Wiley and Sons, UK.
11. Richards, John A. , Jia, Xiuping (2006). Remote Sensing Digital Image Analysis: An Introduction. Fourth Edition, Springer India Pvt. Ltd., New Delhi.
12. Wainwright, John, and Mulligan, Mark (2013). Environmental Modelling: Finding Simplicity in Complexity. Second Edition, John Wiley and Sons Ltd., UK.
13. Andrew Lovett, Katy Appleton (Ed) (2008). Geographic Information System for Environmental Decision Making. CRC Press, Taylor and Francis, Boca Raton, Florida.
14. U.M.Shamsi (2010). GIS Application for Water, Wastewater and Stormwater Systems, CRC Press, Florida
15. Johnson, Lynn E. (2009). GIS in Water Resource Engineering, CRC Press, Boca Raton, Florida.
16. Wang, Yexiao, Ed., (2010). Remote Sensing of Coastal Environment, CRC Press, Florida.

Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: Advanced Environmental Monitoring Techniques

Paper Code: EVS.906

L	T	P	C	Marks
4	1	0	4	100

Unit 1: Introduction

Basic concepts, applications and importance of Environmental Monitoring; environmental monitoring programs and protocols; Environmental laboratories; Standards procedures for the sampling and analytical techniques; Instrumentation, equipment and facilities for environmental sampling and analysis; Reference materials; Representative samples; Precision and accuracy; Measurement of uncertainty; Environmental monitoring data analysis and management. (12 Lectures)

Unit 2: Environmental Monitoring

Ambient air quality monitoring; Stack monitoring; Tail pipe emissions monitoring; Noise monitoring; On-line monitoring; PM_{10}, $PM_{2.5}$, high volume samplers, orsat apparaturs and flue gas analysers.

Sampling of waters and wastewaters; Flow measurement and composite sampling. (12 Lectures)

Unit 3: Chromatography

Chromatography, GC, HPLC and IC; Modern Methods of Microextactions and chromatography. Surface Plasmon Resonance, Raman Spectroscopy and Surface Enhanced Resonance Spectroscopy and their application in environment. (12 Lectures)

Unit 4: Chemosensors and Biosensors

Cation and anion recognition events, ion pair receptors, inclusion phenomenon, self-assembly. Molecular approaches for designing of molecular-guest recognition event. Host guest chemistry, receptor theory, Supramolecular forces, Binding constant, chelate effect, cooperativity, preorganization, complimentarity, Themodynamic and kinetic aspects of supramolecular interactions. Fabrication of Biosensor, physical and chemical methods of conjugation for immobilization, Designing of optical biosensors and electrochemical biosensors with artificial transducers, MEMS and biochips. SWCNTs and their use in designing electrochemical chemo and biosensors.Introduction to the field of biosensors, History, advantages, applications and use of statistical information to analyze biosensor output, design and capabilities of bioselective layers, Biomolecular structure and function. Mass transport and biosensing in a flow stream, Biosensor figures of merit for comparison of approaches, Homogeneous and heterogeneous assays: fluorescence polarization, electrochemical biosensors, Acoustic biosensors, Optical biosensors. (20 Lectures)

Suggested Readings

1. Shukla SK and Srivastava PR, Methodology for Environmental Monitoring and Assessment, IK Publishers, Delhi (1992).
2. Wiersma G, Environmental Monitoring, CRC Press, New York (2004).
3. Patnaik P, Handbook of Environmental Analysis, CRC Press, New York (1997).
4. Standard Methods for Examination of Water and Wastewater: APHA-AWWA-WEF; Boston (1989).
5. Skoog DA, Holler FL and Nieman TA, Principles of Instrumental Analysis , Harcourt College Publishers(1997)

6. Steed, J. W. and Atwood J. L. (2009) Supramolecular Chemistry, 2nd Edition, John Wiley & Sons, USA.
7. Cragg, P. J. (2010) Supramolecular Chemistry: From Biological Inspiration to Biomedical Applications, 1st edition, Springer, USA
8. Li, S., Singh, J., Li, H. and Banerjee, I. A. (2011) Biosensor Nanomaterials Wiley-VCH Verlag GmbH & Co, Germany.
9. Trojanowicz M. (2008) Advances in Flow Analysis Wiley-VCH Verlag GmbH & Co., Germany.
10. Marks, R. S. (2007) Handbook of Biosensors and Biochips, Volume 1&2, John Wiley, USA.
11. Baldini, F., Chester, A.N., Homola, J. and Martellucci, S. (2006) Optical Chemical Sensors, Springer-verlag, USA
12. Mirsky, V. M. (eds.) (2004) Ultrathin Electrochemical Chemo- and Biosensors : Technology and Performance, Springer Series on Chemical Sensors and Biosensors, Vol. 2, Springer-verlag, USA
13. Nass S. J. and Moses,H. L. (eds.) (2007) Cancer Biomarkers: The Promises and Challenges of Improving Detection and Treatment, National Academic Press, USA
14. Rasooly, A., and Herold, K. E., (eds.) (2008) Biosensors and Biodetection: Methods and Protocols Volume 1: Optical-Based Detectors 1st Edition, Humana Press, USA
15. Barceló, D., and Hansen, P. D. (2009) Biosensors for the Environmental Monitoring of Aquatic Systems, The Handbook of Environmental Chemistry, Part 5 / 5J, Springer, USA.

Centre for Environmental Sciences and Technology

Scheme of Courses Ph.D.

Ph.D. Environmental Science and Technology

Course Title: EVS Lab I (Instrumental Methods of Analysis)

Paper Code: EVS.907

L	T	P	Cr	Marks
0	0	2	2	50

1. Familiarization with HPLC, FTIR, AAS, GC-MS, SEM
2. To determine the pH of water, soil and sludge sample
3. Conductivity measurement and conductometric titrations.
4. Adsorption study – Iodine value determination of charcoal.
5. TCLP extract preparation
6. Determination of Gross Calorific Value of fuel/straw samples using Bomb Calorimeter.
7. To determine the kinematic viscosity of the sample by viscometer
8. Determination of flash point of the sample by flash point apparatus
9. To determine the cloud and pour point of the sample
10. To analyze the biogas composition by gas chromatography
11. Precipitation titrations : Solubility product based chloride determination.
12. Flocculation studies of wastewater samples.
13. Complexometric titration for determination of hardness (Total, Ca, permanent and Temporary).
14. Gravimetric determination of Sulphate, Silica content
15. Determination of Sulphide by iodometric titration.
16. Determination of DO, COD and BOD of waste water.