Central University of Punjab, Bathinda

Department of
Environmental Sciences and Technology

Course Structure of Ph.D. Course work (Ph.D. Environmental Sciences and Technology)

Session 2020

Programme Objectives:

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

1. Relate the environmental issues and problems at the local, regional and global level.
2. Apply the acquired skills on various environmental monitoring techniques, instruments, pollution control technologies, data analysis and interpretation.
3. Develop new technologies and action plan to solve the problems of the environment
4. Design experiments to perform research on environmental issues.
5. Formulate the policies, legislations, conventions and protocols associated with the environment.

Semester-I

Sl. No	Paper Code	Course Title	L	T	P	Cr
1	EVS 701	Research Methodology	2	1	0	2
2	EVS 751	Research and Publication Ethics	2	1	0	2
3	EVS 702	Computer Applications	2	1	0	2
4	EVS 703	Biostatistics	2	1	0	2
4	EVS 706	Instrumentation and Analytical Methods	4	1	0	4
5	EVS XXX	Elective I	4	1	0	4
6	EVS 704	EVS Lab I (Computer Applications)	0	0	2	2
7	EVS 705	EVS Lab II (Instrumental methods of Analysis)	0	0	2	2
8	EVS 799	Seminar	0	0	2	2
		Total	**16**		**6**	**22**
5 & 6	EVS 711	Water Treatment Technologies	4	1	0	4
	EVS 712	Biological Wastewater Treatment Technologies	4	1	0	4
	EVS 713	Bioenergy and Bioproducts	4	1	0	4
	EVS 714	Application of Remote Sensing and GIS in Environmental Management	4	1	0	4

***Students may opt any two relevant courses within or outside the Centre**
Synopsis Submission at the end of Semester II
L: Lectures T: Tutorial P: Practical Cr: Credits
Total Marks: Continuous Assessment and End-Term Exam

L	T	P	C
2	1	0	2

Course Title: Research Methodology
Paper Code: EVS 701

Learning Outcomes
Student will be able to

- Formulate research problem and steps involved in research process
- Analyse 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
Meaning and importance of research, Critical thinking, Research approaches; Review of Literature, Identifying gap areas for literature review, formulation of research questions, formulating hypothesis and development of working hypothesis, development of Quantitative and qualitative research; Criteria of good research. (8 Hours)

Unit 2: Research Process
Defining research problem; features of good design; types of research design; Basic principles of experimental designs; Important Experimental designs; (7 Hours)

Unit 3: Scientific writing
Scientific writing, Writing research paper, Poster preparation and presentation and Dissertation. Library Classification systems, e-Library, Reference management, Web-based literature search engines; Plagiarism, copyright issues. (8 Hours)

Unit 4: Sampling: Designing probability and non-probability sampling techniques for research problems, reliability and validity of qualitative and quantitative tools; Interpretation of results and discussion. (7 Hours)

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. 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

Mode of transaction: Class room teaching, Lectures, Group discussions

Course Title: Research and Publication Ethics
Paper Code: EVS 751

L	T	P	Cr
2	1	0	2

Learning Outcomes
Student will be able to

- Apply basics of philosophy of science and ethics
- Identify research misconduct and predatory publications
- Examine open access publications and research metrices
- Analyze plagiarism tools

Unit 1: Philosophy and Ethics- Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgments and reactions.
Scientific Conduct: Ethics with respect to science and research; Intellectual honesty and research integrity; Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP); Redundant publications: duplicate and overlapping publications, salami slicing; Selective reporting and misrepresentation of data.

(8 Hours)

Unit 2: Publication Ethics: Publication ethics: definition, introduction and importance; Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributorship; Identification of publication misconduct, complaints and appeals; Predatory publishers and journals (7 Hours)

Unit 3: Open Access Publishing: Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finder/journal suggestion tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.
Publication Misconduct: Group Discussions - Subject specific ethical issues, FFP, authorship; Conflicts of interest; Complaints and appeals: examples and fraud from India and abroad
Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools. (8 Hours)

Unit 4: Databases and Research Metrics: Databases - Indexing databases, Citation databases: Web of Science, Scopus, etc.
Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite score; Metrics: h-index, g index, i10 index, altmetrics (7 Hours)

Suggested Readings:

1. Lester, James, D. and Lester Jr. J. D. (2007). Principles of Writing Research Papers, Longman, New York.
2. Silverman D. (2000). Analyzing talk and text. In N. Denzin and Y. Lincoln, eds. Handbook of Qualitative Research by, Sage Publications, Thousand Oaks, CA.1993, Longman U.K.
3. John, W. C. (2011). Research Design: Qualitative, Quantitative and Mixed Methods Approaches by, Sage Publications, Thousand Oaks.
4. Seale C. (2004). Social Research Methods: A Reader. Routledge, London.

Mode of transaction: Class room teaching, Lectures, Group discussions, Practical

Course Title: Computer Applications
Paper Code: EVS 702

L	T	P	Cr
2	0	0	2

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

- Use different operating systems and their tools easily.
- List word processing software, presentation software, spreadsheet software and latex.
- Describe networking and internet concepts.
- Apply computers in every field like teaching, industry and research.

Unit 1
Fundamentals of computers: Parts of computers, Hardware, BIOS, Operating systems, Binary system, Logic gates and Boolean algebra.

(7 Hours)

Unit 2
World wide web: Origin and concepts, Latency and bandwidth, Searching the internet, Advanced web-search using Boolean logic, Cloud computing. (8 Hours)

Unit 3
Computer language: Basic DOS commands, AutoHotKey scripting language, HTML and basic structure of a webpage, Designing websites. (7 Hours)

Unit 4
Sharing Data over Network, Computer Configuration, Memory Hierarchy, Software Structure. Introduction to MS Paint, Notepad and Word. Introduction to Word Processing and Microsoft Office, Creating and Saving Documents, Text Formatting, Tables, Document Review Option, Mail Merge, Inserting Table of Contents, Reference Management.

Application software: Spreadsheet applications, Word-processing applications, Presentation applications, Internet browsers, Reference management, and Image processing applications.

(8 Hours)

Suggested readings:
1. Gookin, D. (2007). MS Word for Dummies.Wiley.
2. Harvey, G. (2007). MS Excel for Dummies. Wiley
3. Sinha, P.K., Computer Fundamentals, BPB Publications
4. Bhatt, Pramod Chandra P. (2008). An introduction to Operating systems: Concept and practice. 2nd Edition. PHI learning Pvt. Ltd, New Delhi.

Mode of transaction: Class room teaching, Lectures, Group discussions, Practical

Course Title: Biostatistics
Paper Code: EVS.703

L	T	P	Cr
2	0	0	2

Learning Outcomes: The student 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 Overview of biostatistics

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, Histograms. (7 Hours)

Unit 2: Descriptive statistics

Measures of central tendency- mean, median, mode for discreet and grouped data; measures of dispersion, Moments, Kurtosis and Skewness.

Probability- Events, algebra of events, three basic approaches to probability, combinatorial problems. Axiomatic approach to probability. Conditional probability, Bayes' formula; Probability distributions - Binomial, Poission, Gaussian distribution. (8 Hours)

Unit 3: Sampling and Testing

Experimental design and analysis- Sampling techniques, Sampling theory, Steps in sampling, Collection of data-types and methods. Difference between parametric and non-parametric statistics, Confidence interval, Errors, Levels of significance, Hypothesis testing.

Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots, curve fitting. Error analysis- types of errors, instrumental, statistical, propagation of errors.

(7 Hours)

Unit 4: Comparing means of two or more groups

Student's t-test, Paired t-test, Mann-Whitney U-test, Wilcoxon signed-rank, One-way and two-way analysis of variance (ANOVA), Critical difference (CD), Least significant difference (LSD), Kruskal–Wallis one-way ANOVA by ranks, Friedman two-way ANOVA by ranks, $\chi 2$ test.

Least square fitting: Least square fit to a straight line, polynomial, matrix, arbitrary function. Testing the Fit- Chi square test, Linear correlation coefficient, multi variable correlations, Confidence intervals.

(8 Hours)

Suggested Readings

1. Murray, R. S. and Larry, S. (2017). *Schaum's Outline of Statistics,* McGraw-Hill Education (ISE Editions).
2. Meyer, P. L. (2007). *Introductory Probability and Statistical Applications,* Oxford & IBH Publishers.
3. Hogg, R.V. and Craig, A.T. (2018). *Introduction to mathematical statistics,* Macmillan Pub. Co. Inc.
4. Croxton, F.E. and Cowden, D.J. (2014). *Applied General Statistics*, Taylor & Francis group.

5. Rohtagi, V. K. (2015). *An introduction to probability and statistics*, Wiley India private limited.
6. Carlson, K. A., Winquist, J. R. (2014). *An introduction to statistics: an active learning approach*, New Delhi: Saga publication limited.
7. Mohanty, P. K., Patel, S. K. (2015). *Basic statistics*, New Delhi: Scientific Publishers.
8. Sheldon M. R. (2017). *Introductory to Statistics*, Academic Press, Elsevier.
9. McClave, J. (2018). *Sincich Statistics*, Pearson Publisher.
10. Gupta, S. C. (2019). *Fundamental of Statistics*, Himalayan Publisher.

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

Course Title: Instrumental Methods of Analysis
Paper Code: EVS.706

L	T	P	C
4	0	0	4

Learning Outcomes
Student will be able to:

- Introduce acid base equilibria
- Apply principles and steps in precipitation, complexation and titrations
- Explain principle, instrumentation and application of instruments
- Distinguish steps and working principle of spectrometric and thermogravimetric methods
- Describe the types, principle and applications of chromatographic techniques

Unit 1: Quantitative analysis
Acid-base, complexometric, precipitation and redox titrimetry; Gravimetric analysis – total solids, suspended solids and volatile solids.

(13 Hours)

Unit 2: Instruments
pH meter, Conductivity meter, TDS meter, DO meter, Salinity meter, Ion Selective Coulometry, Anode and cathode stripping voltammetry, dropping mercury electrode(DME), merits and demerits of DME.

(15 Hours)

Unit 3: Spectrometric and Thermogravimetric Methods
U.V. spectrophotometer, fluorescence, Flame photometry, Atomic absorption and atomic emission spectrophotometry, molecular structure determination using X- ray, fluorescence and X-ray diffraction, different types of mass spectrometry and surface plasma resonance.
Thermogravimetric Analysis, Differential Scanning Calorimetry.

(16 Hours)

Unit 4: Separation/ Chromatographic Techniques
Partition coefficient, chromatography, general chromatography, chromatographic methods: Paper, Thin Layer chromatography, Column, High Performance Thin Layer Chromatography (HPTLC), Gas Chromatography (GSC and GLC), GC-MS, High Pressure Liquid Chromatography, Ion Exchange chromatography, Ion/Size Exclusion Chromatography and Electrophoresis.

(16 Hours)

Suggested readings:

1. Skoog D. A., Holler F.L. and Crouch, S. R. (2007). *Principles of instrumental analysis,* USA: Thomson Brooks/Cole Publishers.
2. Harris D. C. (1948). *Exploring Chemical Analysis*, 3rd edition. W. H Freeman & Company.
3. Holler F. J, Crouch S.R. (2014). *Skoog & West's Fundamental of Analytical Chemistry,* 9th edition, CENGAGE learning.
4. Ahluwalia V. K. (2015). *Instrument Methods of chemical analysis,* Ane Books Pvt. Ltd.
5. Ewing, G. W. (1985). *Instrumental methods of chemical analysis, 5th edition,* USA: McGraw Hill Publications
6. Patnaik, P. (2010). *Handbook of environmental analysis,* CRC Press, USA
7. Svehla G. (1996). *Vogel's qualitative inorganic analysis, 7th Edition,* Prentice Hall, USA
8. Wiersma G. (2004). *Environmental monitoring,* CRC Press, UK.
9. 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.
10. Shukla, S. K., Srivastava, P. R. (1992). *Methodology for environmental monitoring and assessment,* New Delhi: Commonwealth Publishers.
11. Rajvaidya, N., Markandey, D. (2005). *Environmental Analysis and Instrumentation*, APH Publisher.
12. Chatwal, G. R., Anand, S. K. (2013). *Instrumental Methods of Chemical Analysis,* Himalaya Publishing House, New Delhi.
13. Skoag, D. A., Holler, F. J., Crouch, S. R. (2007). *Principles of Instrumental Analysis,* CENGAGE Learning.
14. Rouessac, F., Roussac, A. (2008). *Chemical analysis: modern instrumentation and techniques,* Wiley, England.

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

Course Title: EVS Lab I (Computer Applications)
Paper Code: EVS.704

L	T	P	C
2	0	0	2

Learning Outcomes

Student will be able to

- Develop skill on computer operational systems
- Demonstrate databases and statistical packages
- Use different operating systems and their tools easily.
- Apply computers in every field like teaching, industry and research.

1. Familiarization with Advances in MS Office (MS WORD, MS Excel)
2. Familiarization with SPSS
3. Analysis of variance
4. Chi square test
5. t-test
6. F-test
7. Z-test

Suggested Readings:

1. Sinha, P.K. Computer Fundamentals. BPB Publications.
2. Goel, A., Ray, S. K. 2012. Computers: Basics and Applications. Pearson Education India.
3. Microsoft Office Professional 2013 Step by Step https://ptgmedia.pearsoncmg.com/images/9780735669413/samplepages/9780735669413.pdf

Mode of transaction: Class room teaching, Lectures, Group discussions, Practical

Course Title: EVS Lab II (Instrumental Methods of Analysis)
Paper Code: EVS.705

L	T	P	Cr
0	0	2	2

Learning Outcomes

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
- Distinguish steps and working principle of spectrometric and thermogravimetric methods
- Describe the types, principle and applications of chromatographic techniques
- Demonstrate properties of fuel samples

1. Familiarization with GC, HPLC
2. To determine the pH of water, soil and sludge sample
3. Conductivity measurement and conductometric titrations.
4. Determination of Gross Calorific Value of fuel/straw samples using Bomb Calorimeter.
5. To determine the kinematic viscosity of the sample by viscometer
6. Determination of flash point of the sample by flash point apparatus
7. To determine the cloud and pour point of the sample
8. To analyze the biogas composition by gas chromatography
9. Precipitation titrations: Solubility product based chloride determination.
10. Complexometric titration for determination of hardness (Total, Ca, permanent and Temporary).
11. Determination of Sulphide by iodometric titration.
12. Determination of DO, COD and BOD of 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.

Mode of transaction: Class room teaching, Lectures, Group discussions, Practical

Course Title: Water Treatment Technologies

Paper Code: EVS 711

L	T	P	Cr
4	1	0	4

Learning Outcomes

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

- Apply water purification techniques to provide safe drinking water
- Develop wastewater treatment technologies for abatement of water pollution
- Inspect the working of water and wastewater treatment plants
- Formulate new wastewater discharge standards

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.

(15 Hours)

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. (15 Hours)

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.

(15 Hours)

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.

(15 Hours)

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.
9. Patnaik P. (2011). Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes. CRC Press.

Mode of transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point

Course Title: Biological Wastewater Treatment Technologies
Paper Code: EVS 712

L	T	P	C
4	1	0	4

Learning Outcomes
At the completion of the course, the student will be able to:
- Apply water purification techniques to provide safe drinking water
- Develop wastewater treatment technologies for abatement of water pollution
- Inspect the working of water and wastewater treatment plants
- Formulate new wastewater discharge standards

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 Hours)

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 Hours)

Unit 3: Biological Nutrient removal
Nitrogen removal - Biological nitrification and denitrification - process description, microbiology & technologies; Biological phosphorus removal - process description, microbiology & technologies (8 Hours)

Unit 4: Biological sludge stabilization
Anaerobic digestion, aerobic digestion, composting - process description and microbiology; Sludge pre-treatment. (12 Hours)

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 HandD. 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.

Mode of transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point

Course Title: Bioenergy and Bioproducts
Paper Code: EVS 713

L	T	P	C
4	1	0	4

Learning Outcomes: Student will be able to
- Examine the scope of different types of bioenergy
- Integrate the fermentation principles for energy and value added products
- Apply biopolymer to industrial
- Develop sustainable model for waste to energy production

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 Hours)

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 Hours)

Unit 3: Biopolymers
Natural biopolymers- Cellulose, Protein, Nucleic acids; Biocomposites, Biofibres; Bioplastics:Types- Poly hydroxyalkanoates, Polylactic acid, Properties, Feedstocks; Production process, Biodegradation; Applications, Environmental impacts. (14 Hours)

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 Hours)

Suggested readings:

1. Brain McNeil and Linda Harvey. (2008). Practical Fermentation Technology. Wiley Publishers, United Kingdom.
2. EIRI Board. (2010). Modern Technology of Bioprocessing (Fermentation, Food, Enzyme, Pharmaceutical Industrial, Agricultural and Energy). Engineers India Research Institute Publishers,New Delhi.
3. Johnson, R.M., Mwaikambo,L.Y. and Tucker.N. (2003). Biopolymers. Smithers Rapra Technology Publishers, United Kingdom.
4. Kole, C., Joshi,C.P, Shonnard, D.R. (2019). Handbook of bioenergy crop plants. CRC Press
5. Konur, O. (2017). Bioenergy and Biofuels. CRC Press
6. Levy, S.L. (2011). Biofuels, Biorefinery and renewable energy: Issues and Developments. Nova Science Publishers, USA.
7. Michele Aresta, Angela Dibenedetto and Frank Dumeignil. (2012). Biorefinery: From Biomass to chemicals and fuels. Walter De Gruyter Publishers, Germany.
8. Pandey, A., Larroche, C. and Carlos Ricardo Soccol. and Claude –Gilles Dussap. (2009). Advances in Fermentation Technology. Asiatech Publishers Inc, New Delhi
9. Stansbury, P.F. (1999). Principles of Fermentation Technology, 2nd Edition. Butterworth-heinemann. Burlington, MA.
10. Wagemann, K. and Tippkötter, N. (2019). Biorefineries:Advances in Biochemical Engineering/Biotechnology, 1st ed. 2019 Springer

Mode of transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point

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

L	T	P	Cr
4	1	0	4

Paper Code: EVS 714

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 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 Hours)

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 Hours)

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, Unsupervised and supervised classification, accuracy assessment. (18 Hours)

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 Hours)

Suggested readings

1. Lillisand, T. M., Keifer, R. W. (2007). *Remote sensing and image interpretation,* USA: John Willey and Sons.
2. Barrett, E. C. and Curtis, L. F. (1999). *Introduction to environmental remote sensing,* USA: Chapman and Hall Publishers.
3. Joseph, G. (2003). *Fundamentals of remote sensing,* Hyderabad: Universities Press.
4. Chang, K. (2002). *Introduction to geographic information systems,* USA: Tata McGraw-Hill.
5. Curran, P. J. (1988). *Principles of Remote Sensing,* ELBS: Harlow Longman Scientific and Technical.
6. Skidmore, A. (2010). *Environmental modelling with GIS and remote sensing,* New Delhi, Crc Press.
7. Shamsi, U. M. (2012). *GIS applications for water, wastewater, and stromwater systems,* CRC Press.
8. Bhatt, B. (2011). *Remote sensing and GIS,* New Delhi: Oxford university press.
9. Abbasi, T. (2010). *Remote sensing GIS and wetland management*, Discovery publishing house.
10. Shellito, B. (2017). *Geospatial technologies,* 4th edition, W. H. Freeman Publisher.
11. Singh, C. K. (2018). *Geospatial Applications for natural Resources Management,* CRC Press.

Mode of transaction: Lecture, demonstration, E-tutoring, discussion, assignments, case study, power point, e-learning